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AUTHOR Manning, Phillip R.; And Others
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ABSTRACT

To gather data on the effects of different modes of instruction on physician achievement in plotting mean P, O, RS, and T receptiors in electrocardiography, researchers chose a random sample of physicians who had taken a correspondence course on electrocardiography during the previous 5 years from the University of Southern California School of Medicine. The 500 subjects were randomly assigned to two instructional groups and given a 30-item test requiring the subject to plot vectors from 12-lead electrocardiogram tracings. The results were analyzed using a computer program. There was no significant difference using textbook, programed textbook, lecture-workshop, and lecture-demonstration on achievement tests, but a significant difference among means of instructional time was found. The second part of the study tested the hypothesis that among the groups of physicians there were no significant differences in the results of the test of knowledge requiring the application of the information taught by le[illegible] slides, set-clinic with slides, lecture with slides and a [illegible] patient, and bedside teaching with the patient that was films and slides. Volume II of the study is a programed text on spatial analysis of the electrocardiogram. (BC)

FINAL REPORT

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Director	Phil R. Manning, M . Professor of Medicine Associate Dean for Postgraduate Affairs School of Medicine University of Southern California
Evaluation	Stephen Abrahamson, Ph. D. Professor of Education Director - Research in Medical Education School of Medicine University of Southern California
Research Assistant	Donald A. Dennis, M. A.
ECG Instructor	James V. Dooley, M. D. Associate Clinical Professor of Medicine University of Southern California
ECG Instructor	Irwin Hoffman, M. D. Associate Clinical Professor of Medicine University of Southern California
ECG Instructor	Julien H. Isaacs, M. D. Assistant Clinical Professor of Medicine University of Southern California
Instructor - Phase II	Telfer B. Reynolds, M. D. Professor of Medicine University of Southern California
Artist	Lynda J. Dummel
Secretary	Mary E. Simons

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PART I

PHASE I

SPATIAL ANALYSIS OF THE ELECTROCARDIOGRAM

CHAPTER I

CHAPTER I

PRESENTATION OF THE PROBLEM

Effective continuing education for the practicing physician presents a complex and difficult problem. Characteristically, the practicing physician receives his additional education during passive participation in bedside teaching. Transfer of information has been emphasized; the opportunity for more-active learning has been limited. In addition, teaching of facts has been emphasized with little concern for what learning takes place and whether or not the facts can be used in the practice of medicine.

It has become apparent that presentations that are limited to the transfer of information do not assure that physicians participating in continuing education will offer superior medical care. In fact, there is little or no evidence that behavior is changed by attendance in conventional postgraduate courses. It is, therefore, important that the role of transferring of information be not over-estimated but understood in its proper perspective as a part of the educational process. Physicians must have the opportunity of learning facts, concepts, principles, and procedures in the most efficient and effective way.

The purpose of this contract was to provide insight to more efficient and effective methods of teaching physicians in selected

instructional modes and content which could be applied to similar teaching situations.

STATEMENT OF THE PROBLEM OF PHASE I

Phase I, Section A

The problem of Phase I, Section A of this study was to test the following hypotheses:

1. There are no significant differences in the results of a test of achievement requiring the application of the rules of Spatial Analysis of the Electrocardiogram among the groups of physicians using different modes of instruction: (1) a textbook, Spatial Analysis of the Electrocardiogram, (2) A Programmed Text on Spatial Analysis of the Electrocardiogram, (3) lecture-workshop, and (4) lecture-demonstration.
2. There are no significant differences in instructional time to learn the rules of Spatial Analysis of the Electrocardiogram among the groups of physicians using the different modes of instruction: (1) textbook, (2) programmed textbook, (3) lecture-workshop, and (4) lecture-demonstration.
3. There are no significant differences among the groups when the means of the predicted gain scores for achievement are adjusted for the amount of instructional time.
4. There are no significant differences in the results of a delayed post-test of achievement requiring the application of the rules of Spatial Analysis of the Electrocardiogram among

the groups of physicians using different modes of instruction: (1) textbook, (2) programmed textbook, (3) lecture-workshop, and (4) lecture-demonstration.

Phase I, Section B

The problem of Phase I, Section B of this study was to test the following hypotheses:

1. There are no significant differences in the results of a test of achievement requiring the application of the rules of Spatial Analysis of the Electrocardiogram among two groups of physicians using two different modes of instruction as a correspondence course: (1) a textbook, Spatial Analysis of the Electrocardiogram, and (2) A Programmed Text on the Spatial Analysis of the Electrocardiogram.
2. There are no significant differences in instructional time to learn the rules of Spatial Analysis of the Electrocardiogram among the groups of physicians using two different modes of instruction as a correspondence course: (1) textbook and (2) programmed textbook.
3. There are no significant differences between the two groups when the means of the predicted gain scores for achievement are adjusted for the amount of instructional time.

Phase I, Section C

1. There are no significant differences in the results of a test of clinical skill in plotting mean cardiac vectors requiring

the application of the rules of Spatial Analysis of the Electrocardiogram among the groups of physicians using the three modes of instruction: (1) lecture-workshop, (2) lecture-demonstration, and (3) A Programmed Text on Spatial Analysis of the Electrocardiogram.

2. There are no significant differences in instructional time to learn the rules of Spatial Analysis of the Electrocardiogram among the three groups of physicians using the three different modes of instruction: (1) lecture-workshop, (2) lecture-demonstration, and (3) a programmed textbook.

3. There are no significant differences among the groups when the means of the predicted grain scores for achievement are adjusted for the amount of instructional time.

Phase I, Section D

The problem of Phase I, Section D of this study was to test the following hypotheses:

1. There are no significant differences in the results of a test of clinical skill in plotting mean cardiac vectors requiring the application of the rules of Spatial Analysis of the Electrocardiogram between groups of freshman medical students using the two modes of instruction: (1) programmed textbook, and (2) textbook.

2. There are no significant differences in instructional time to learn the rules of Spatial Analysis of the Electrocardiogram

between the groups of freshman medical students using the different modes of instruction: (1) programmed textbook and (2) textbook.

3. There are no significant differences among the two groups when the means of the predicted gain scores for achievement are adjusted for the amount of instructional time.

STATEMENT OF THE PROBLEM OF PHASE II

The problem of Phase II of this study was to test the hypothesis there are no significant differences in the results of a test of knowledge requiring the application of information among the groups of physicians taught by the following different modes of instruction: (1) lecture with slides, (2) set-clinic with slides, (3) lecture with slides and a film of the patient, and (4) bedside teaching with slides.

STATEMENT OF THE PROBLEM OF PHASE III

The problem of Phase III of this study was to develop a methodology by which interviewing techniques may be utilized to obtain precise data from a sample of physicians participating in the programs of Phases I and II.

SIGNIFICANCE OF THE STUDY

A physician's ability to perform efficiently and effectively and to keep abreast the advancement in medical knowledge are the concern of all society.

The realization that learning is largely dependent upon events

in the environment with which the individual interacts makes it possible to view learning as an occurance that can be examined more closely and understood more profoundly. Learning is not simply an event that happens naturally. Thus, it is important that physicians have the opportunity of learning facts, concepts, principles and procedures in the most efficient and effective way. This dependence of learning on environmental circumstances implies a great responsibility on the instructor or the developer of the instructional package.

Evaluation of the efficiency and effectiveness of instructional packages for the practitioner and of the various teaching methods used for postgraduate medical education will provide data which may influence those in postgraduate medical education to examine more closely their educational practices and philosophy.

CHAPTER II

TECHNIQUES AND PROCEDURES

GENERAL DESIGN OF THE STUDY FOR PHASE I AND II

The experiment was designed to gather data on the effects of different modes of instruction on physician achievement.

Statistical Techniques

Measurement of achievement. – One of the major difficulties of educational research is the inability to set up experimental groups at will. Often, the investigator must use intact groups. Therefore, the statistic chosen was the analysis of covariance, which is a form of analysis of variance, "that tests the significances of differences between means of final experimental data by taking into account and adjusting initial differences in the data."[1] The analysis of covariance analyzes the differences between experimental groups on a Y variable, the dependent variable on which the comparisons are made, after taking into account either initial differences in the Y measures of differences in some pertinent independent variable, the covariate or predictor variable. Also, the analysis of covariance statistically matches the subjects for the experimentor, obtaining the benefits of matching

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[1]Kerlinger, Fred N., Foundations of Behavorial Research (New York: Holt, Rinehart and Winston, Inc., 1966), p. 347

without the difficulty of arranging the matching.[2]

Learning time and achievement. – In determining the relationship between time spent in learning and the achievement scores, it was necessary to develop a technique and procedure that would not use proportions and give meaningful interpretations of this relationship. One problem in working with gain scores or the differences between pre-and posttest scores is the unreliability of these scores.[3] One method to overcome this problem of unreliability is regression of the posttest scores on the pretest scores for each group separately.[4] Then, one obtains the predicted posttest score for each individual, a reliable gain score is obtained. Analysis of covariance was used with the reliable gain scores as the dependent variable and the time score as the covariate.

Other Statistics Used

The Scheffé Test for Multiple Comparisons was used to make comparisons between sets of means.[5] The Scheffé test was used since

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[2] Ibid, p. 348

[3] Robert L. Thorndike and Elizabeth Hagen, Measurement and Evaluation in Psychology and Education (second edition: New York: John Wiley and Sons, Inc., 1961), pp. 190-193.

[4] Procedure suggested by Dr. Richard M. Wolf, Assistant Professor of Education, The University of Southern California.

[5] Edwards, Allen L., Experimental Design in Psychological Research (Revised Edition; New York: Holt, Rinehart and Winston. 1960), pp. 154-156.

the comparisons could not be planned in advance and was used only when a significant F ratio appeared in the analysis of variance table. The F test was used for comparing significance of the variance between groups where it was felt to be necessary.

Instructional Variables

Each of the subjects was randomly assigned, using a table of random numbers to one of the instructional groups for each section of Phase I and II. Each group was randomly assigned to an instructional mode.

CHAPTER III

SUBJECTS, TECHNIQUES AND PROCEDURES OF PHASE I, SECTION A

SUBJECTS

The subjects for Phase I, Section A, of this study were the participants of the 17th Annual West Coast Counties Regional Post-graduate Institute, March 2-3, 1967.

DESIGN OF THE STUDY

The experiment was designed to gather data on the effects of different modes of instruction on physician achievement in plotting mean P, QRS, and T vectors in electrocardiography. It was hypothesized (1) the results of a test of clinical skill in plotting mean cardiac vectors would show scores not significantly different among four modes of instruction, (2) the differences in instructional times of the four modes would show no significant difference among the means, (3) there are no significant differences among the groups when the means of the predicted gain scores for achievement are adjusted for the amount of instructional time, and (4) there are no significant differences in the results of a delayed posttest of achievement requiring the application of the rules of Spatial Analysis of the Electrocardiogram among the groups of physicians using different modes of instruction:

(1) textbook, (2) programmed textbook, (3) lecture-workshop, and (4) lecture-demonstration.

Statistical Techniques

Measurement of achievement. The statistic chosen was analysis of covariance to test the significance for differences between the means of the posttest data by taking into account and adjusting for initial difference in the pretest data.

Achievement was measured at the time of the instructional treatment using pretest and posttest data and then at the end of this current study with pretest data and delayed posttest data collected over the period of time beginning three months after the instructional treatment and continuing to May 1, 1968.

Learning Time and Achievement. The relationship between instructional time and the achievement scores was determined using the techniques and procedures described in Chapter II under "Statistical Techniques." Analysis of covariance was used with the reliable gain scores as the dependent variable and the time data as the covariate.

Experimental Variables

Instructional Variables. The subjects were randomly assigned to each of four groups. Each group was randomly assigned to an instructional mode.

The two groups assigned, respectively, to the programmed test book and the standard text were taught entirely by the respective mode.

The lecture-workshop and lecture-demonstration groups were taught by the three instructors who had written both text modes. Those subjects in the lecture-demonstration heard a standard lecture that was supplemented by a demonstration of the plotting of cardiac vectors by the faculty. Those subjects in the lecture-workshop heard a standard lecture and had the opportunity to plot mean cardiac vectors under the supervision of the faculty.

The plotting of the mean cardiac vectors in the horizontal and frontal planes of the standard 12-lead electrocardiogram was the factual content for the four modes. This subject was chosen because it was one generally not used by the physicians who were to be tested and was a subject that could be taught in a period of approximately three hours. Therefore, the effects of the instruction were clearly distinguishable and isolated from other effects.

PROCEDURES

Preparation of Instructional Materials

In the preparation of the instructional modes, the following criteria as suggested by Cheris were followed: (1) identical content in each mode, (2) optimum presentation by each mode, (3) appropriate study conditions for each mode, (4) prior knowledge by the subject of test conditions, (5) accurate measurement of learning time, and (6) an unbiased criterion test.[1]

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[1]Barbara H. Cheris, "On Comparing Programming and Other Teaching Methods," The Journal of Medical Education, Vol. 39 (March, 1964,) 305.

The three authors, Irwin Hoffman, M. D., Julien H. Isaacs, M.D., and James V. Dooley, M. D., together spent over 3000 hours in preparation of the programmed text.[2] The investigators and the authors spent another 300 hours writing the text mode.[3] The phraseology of the two modes were identical, followed the same sequence, contained identical concepts, definitions, terminology, examples, and the same illustrations. The lectures were taken direcely from the textbook. The slides used in the lecture-demonstration and the lecture-workshop were photographed from the original illustrations used in the programmed text and the standard textbook.

The text differed from the program in being less repetitious and did not require active participation by the subject. The more probable wrong answers appearing as choices in the program were included and explained in the standard text. The programmed text was scrambled and in a modified linear format, having two to four choices per frame.

Preparation of the Test

The test was developed by the three authors and the researchers.[4] The thirty item test required the subjects to plot vectors from standard 12-lead electrocardiogram tracings rather than merely elicitating a

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[2]Appendix A

[3]Appendix B

[4]Appendix C

demonstration of knowledge gained. A reliability coefficient .93, was determined by the subdivided test procedure.[5]

Preparation of Packets for Subject

Each subject was given a four digit identification number. The first digit signified the treatment group, 1-4. The last three digits signified the numerical position of the subject's name on the original registration list which was used for the randomization of the subjects to the four treatment groups.

The packets containing the materials to be used in this experiment were prepared before the date of the study. Each packet contained the following items: (1) Questionaire sheet to be filled in by the subject, (2) P, QRS, and T orientation sheet, (3) Pad of Frontal and Horizontal Plane reference figures, (4) Test booklet with a salmon colored pretest answer sheet inserted inside the back cover, (5) a legal size envelope enclosing a buff colored posttest answer sheet, and (6) for the lecture packets only, a stapled group of seven ECG tracings.[6]

The following items were prenumbered with each subject's identification number: (1) the packet, (2) the information sheet, (3) the pretest answer sheet, (4) the legal size envelope, (5) the inserted posttest answer sheet in the legal size envelope, and (6) the institute name badge which was given to the subject upon registration.

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[5]Thorndike, op. cit., pp 178-180

[6]Appendix D

Lecture-demonstration and Lecture-workshop Treatments

The instructional area for both the lecture-workshop and the lecture-demonstration was arranged according to the recommendations in Audiovisual Projection (paraphrased):[7] (1) for square-shaped rooms, more people can sit in the effective viewing area if the projection axis is the same as the diagonal of the room; (2) a matte screen should be used since this type of screen diffuses light evenly in all directions; (3) viewers should be no more than 30° to the side of the projection axis to avoid image distortion: (4) the front row of viewers should be no closer to the screen than two image widths, and the back row of viewers should be no farther from the screen than six times the image width.

A matte screen with an image width of ten feet was chosen in accordance with the recommendations for the screen size. A Kodak Carousel 2" x 2" slide projector, Model 800 with an Ektanar 4" to 6" zoom lens was used to project the slides. The projected image filled the screen area. The projected images were black and white line drawings and did not necessitate complete darkening of the room. It was left light enough so that notes could be taken during the lecture.

Before each lecture session began the packets were distributed numerically in order and a pencil placed by each packet. After the

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[7]Eastman Kodak Company, Audiovisual Projection, (Rochester, N.Y." Eastman Kodak Company, Motion Picture and Educational Markets Division, Pamphlet No. S-3), pp. 5-8.

subjects were seated, Phil R. Manning, M.D. gave the introduction and identified the contents of the packets. Each subject was asked to fill out the questionaire form. The Subjects were then told that the directions, superior, inferior, etc., in the test booklet pertained to the figures on the reference pad. A transparency of the P wave, QRS complex and the T wave orientation sheet was shown by overhead projection and the ECG tracings were explained. Transparencies of the course prerequisites and the course goals were projected and read aloud.

Pretest. – The subjects were asked to open their test booklets to the first page, the directions. After these were read aloud, questions were asked for. There were none. Since the subjects were to plot P, QRS, or T vectors, they were warned to be certain as to which wave the question referred. They were also told not to be discouraged if they could not answer any of the test items. The proctor noted the time and the subjects were told to begin. The directions indicated that each subject had thirty minutes to complete the test. They were advised when fifteen minutes of the time remained. At the end of thirty minutes they were requested to stop and to place the test booklet back in the large packet. The answer sheets were collected.

Experimental Treatment. – The contents of the lecture were divided in the following manner:

For the lecture-demonstration

(1) Irwin Hoffman, M.D., Chapter I, Section I through Part 9 covering the unipolar leads, axes and fields, using 50 illustrations. The estimated time was

thirty minutes.

(2) James V. Dooley, M. D., Section I, Part 10 through Section II, frontal plane leads and mean frontal QRS vector, using forty-five illustrations. The estimated time was thirty minutes.

(3) Julien H. Isaacs, M. D., Section III, mean horizontal QRS vector and the summary, using thirty-two illustrations. The estimated time was thirty minutes.

For the lecture-workshop

(1) Irwin Hoffman, M. D., Chapter I, Section I through Part 9 covering the unipolar leads, axes and fields, using fifty illustrations. The estimated time was thirty minutes.

(2) James V. Dooley, M. D., Section I, Part 10 through Section II, Example 1, frontal plane leads and mean frontal QRS vector using twenty-eight illustrations. Estimated time was fifteen minutes.

(3) Julien H. Isaacs, M. D., Section III, mean horizontal QRS vector and summary, using 18 illustrations. The estimated time was fifteen minutes.

Posttest. — At the end of the instructional period, the subjects were asked to take the legal size envelope out of the packet and to remove the answer sheet. They were then asked to take the test again. The directions were read aloud again. They were told to begin and advised when fifteen minutes of the time remained. At the end of thirty

minutes, they were requested to stop and place the test booklet back in the packet. The answer sheets were collected and then the packets. Care was taken to insure that an answer sheet and a packet were collected from each subject. The subjects were then dismissed.

Programmed Text and Textbook Treatments

Before the textbook and programmed treatment began, the packets were distributed numerically in order anda pencil placed by each packet. The packets for the programmed textbook treatment were placed six to a table and in one-half of the room. The programmed textbooks were distributed six to a table. The packets for the textbook treatment were distributed six to a table in the other half of the same room. The textbooks were distributed six to a table. The room was adequately lighted for reading and standard procedures for controlling the noise level were followed.

After the subjects were seated, Phil R. Manning, M.D., gave the introduction and identified the contents of the packets. Each subject was asked to fill out the questionaire form. The subjects were then told that the directions, superior, inferior, etc., in the test booklet pertained to the figures on the reference pad. A transparency of the P wave, QRS complex and the T wave orientation sheet was shown by overhead projection and the ECG tracings were explained. Transparencies of the course prerequisites and the course goals were projected and read aloud.

Pretest. —The subjects were asked to open their test booklets to the first page, the directions. After these were read aloud, it was

asked if there were any questions. There were none. Since the subjects were to plot P, QRS, and T vectors, they were warned to be certain as to which wave the question referred. They were also told not to be discouraged if they could not answer any of the test items. The directions indicated that each subject had thirty minutes to complete the test. They were advised at fifteen minutes of the remaining time. At the end of thirty minutes they were requested to stop and to place the test booklet in the large packet. The answer sheets were collected with care taken to insure that an answer sheet was collected from each subject.

Experimental Treatment. -- The subjects were told to take the textbooks in the center of the table. Directions for the programmed textbook were read aloud and questions were answered. The subjects were requested to record, on their packet, the time that they began to read the text and when they completed the text. They were instructed to begin reading. The subject was asked to raise his hand upon completing the text, and further directions were given to him by the proctor.

Posttest. -- At the end of the instructional period for each subject, he raised his hand. The proctor instructed him to take the test booklet and the legal size envelope out of the packet. He was then instructed to record the time at the top of the test answer sheet found in the envelope. The subject was asked to not allow more than thirty minutes for the posttest and to write the time of completion below the other time. When each subject completed the test, the answer sheet was collected as well as the packet and the text. Care was taken to insure that an answer sheet was collected from each subject. The subject was

then dismissed.

Delayed Posttest

Approximately three months after the experimental treatment, packets were readied for mailing to the participants. Each packet contained an addressed cover letter which explained the need for the delayed posttest, gave instructions for completing the delayed posttest and returning it in the stamped self-addressed envelope.[8] The packet also contained the test booklet with the following items inside the front cover: (1) a P, QRS, and T orientation sheet, (2) a pad of frontal and horizontal plane reference figures, (3) a white answer sheet with the attached legal size stamped self-addressed envelope for the return of the completed posttest.[9] The posttest answer sheet had the subject's identification number written in the appropriate space.

Follow up on the delayed posttest: If a participant did not return the posttest answer sheet within a month's time, a follow-up letter and a complete new packet was mailed to the subject.[10] At most, three follow-up letters with a complete packet were sent to each of those that did not respond with a completed delayed posttest.

Scoring

The investigator, using an answer key with squares cut out to reveal the correct answer when laid upon an answer sheet, scored the tests. The number of correct answers was written at the top of the

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[8] Appendix E
[9] Appendix D
[10] Appendix F

answer sheet. Also tabulated were the number of correct answers for the odd numbered items and the even numbered items. These scores were added as a reliability check on the scoring. The scores for each individual were transferred to a master sheet where the subjects were listed by name and identification number and the instructional time for each individual was listed.[11]

The above data was punched in IBM computer cards and 100% verified. The appropriate statistical techniques were used to analyze the data. Computer programs were used for all statistical computations.

SUMMARY

The subjects for this study were participants of the 17th Annual West coast Counties Regional Postgraduate Institute. The instructional modes and the test were developed. The subjects were randomly assigned to each of four instructional groups. The subjects were pretested, given the appropriate instructional treatment, and posttested. Standard controls of light intensity, noise level, and duration of the tests were followed. The data were collected and treated statistically with analysis of covariance and analysis of variance using computer programs.

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[11] Appendix G for raw data by identification number

CHAPTER IV

PRESENTATION OF THE DATA, FINDINGS AND INTERPRETATIONS OF PHASE I, SECTION A

PRESENTATION OF THE DATA

Section A of Phase I of this study was to investigate the hypothesis:

1. There are no significant differences in the results of a test of achievement requiring the application of the rules of Spatial Analysis of the Electrocardiogram among the groups of physicians using different modes of instruction: (1) a textbook, Spatial Analysis of the Electrocardiogram, (2) A Programmed Text on Spatial Analysis of the Electrocardiogram, (3)lecture-workshop, and (4) lecture-demonstration.
2. There are no significant differences in instructional time to learn the rules of Spatial Analysis of the Electrocardiogram among the groups of physicians using the different modes of instruction: (1) textbook, (2) programmed textbook, (3) lecture-workshop, and (4) lecture-demonstration.
3. There are no significant differences among the groups when the means of the predicted gain scores for achievement are adjusted for the amount of instructional time.
4. There are no significant differences in the results of a

delayed posttest of achievement requiring the application of the rules of Spatial Analysis of the Electrocardiogram.

Table I presents the results of the pre-and posttest and the adjusted means for all four methods. The results of the analysis of variance on the pretest data is presented in Table II.

TABLE I

RESULTS OF PRE-AND POSTTESTS

Method	Pretest $\bar{X}$	Pretest S.D.	Posttest $\bar{Y}$	Posttest S.D.	$\bar{Y}-\bar{X}$	$\bar{Y}'$	N
Programmed text	6.1	7.4	22.0	8.5	15.9	22.1	37
Lecture-workshop	3.4	6.9	22.4	7.3	19.0	23.5	40
Textbook	9.0	8.0	24.4	7.1	15.4	23.4	35
Lecture-demonstration	7.2	9.0	22.4	8.2	15.2	22.8	36
All Groups	6.3	8.0	22.8	7.8	7.8	16.5	148

TABLE II

RESULTS OF ANALYSIS OF VARIANCE ON PRETEST DATA

Source	S.S.	d.f.	M.S.	F
Between groups	616.3	143	20.54	3.35*
Within groups	8822	144	61.27	
Total	9438.3	147		

*Significant $p < .05$

It can be seen that the differences among the means on the pretest were significant beyond the .05 level of confidence.

Table III presents the results of analysis of variance on the posttest data.

TABLE III

RESULTS OF ANALYSIS OF VARIANCE ON POSTTEST DATA

Source	S.S.	d.f.	M.S.	F
Between groups	127.4	3	42.47	.70 N.S.
Within groups	8729	144	60.62	
Total	8856.4	147		

Table III shows that the differences among the means for the groups on posttest data was not significant.

The results of analysis of covariance is presented in Table IV.

TABLE IV

RESULTS OF ANALYSIS OF COVARIANCE (ACHIEVEMENT)

Source	S.S.	d.f.	M.S.	F
Adjusted means	66.6	3	22.19	.4 N.S.
Within groups	7471.5	143	52.25	
Total	7538.1	146		

The correlation coefficient within groups was .38. The correlation coefficient between means was .70 and the correlation coefficient total Y on X was .39.

Since the correlation coefficient within groups and the correlation coefficient total Y on X are about the same, the slopes of the

four regression lines are the same. This indicates that the relationship between the Y variable, the posttest, on which we made the comparisons and the covariate X, the pretest, are the same for each group. With the slopes of the regression lines the same for the four groups and the F ratio was not significant, the researchers conclude that the four groups were not significantly different in achievement as the result of the four modes of instruction.

Table V presents the results of the time, in minutes, used for instruction in each of the four modes. The difference in N was a result of some of the subjects not listing their instructional time as asked for by the researcher.

TABLE V

TIME IN MINUTES FOR THE FOUR MODES

Method	Mean	S.D.	N
Programmed text	72.8	16.2	22
Lecture-workshop	80.0	.0	40
Textbook	48.9	20.2	29
Lecture-demonstration	90.0	.0	36

Table VI presents the results of the one way analysis of variance for time. As shown, the F ratio was significant beyond the .01 level and the intraclass correlation was .70. The intraclass correlation is a measure of the relationship of being a member of a certain treatment group to getting a certain score on the outcome variable.

TABLE VI

ANALYSIS OF VARIANCE TABLE FOR TIME

Source	S.S.	d.f.	M.S.	F.	R
Between groups	28935.1	3	9645.05	70.12*	.70
Within groups	16918.6	123	137.55		
Total	45853.7	126			

*p < .01

The results of Scheffé's test for multiple comparisons on the time for the four groups are presented in Table VII. The Scheffé test is quite conservative and Scheffé suggests that one may consider the .10 level of significance rather than the .05 level of significance.

TABLE VII

RESULTS OF THE SCHEFFÉ TEST ON INSTRUCTIONAL TIME

For the following comparisons, the difference between means was significant at .01.

1. Programmed text versus text.
2. Programmed text versus lecture-demonstration.
3. Text versus lecture-workshop.
4. Text versus lecture-demonstration.

For the comparison of the lecture-workshop versus lecture-demonstration, the difference between the means was significant at the .10 level.

The results of the within group regression analysis to determine the predicted gain for each group is shown in Table VIII.

TABLE VIII

PREDICTED GAIN SCORES

Method	Mean	S.D.	N
Programmed text	16.14	6.08	22
Lecture-workshop	17.95	4.27	40
Textbook	14.93	6.12	29
Lecture-demonstration	14.44	5.91	36

The result of the analysis of covariance using the reliable gain scores as the dependent variable and the time score as the covariate is presented in Table IX. As noted, the F ratio was significant beyond the .01 level.

TABLE IX

RESULTS OF ANALYSIS OF COVARIANCE TABLE
(TIME AND PREDICTED GAIN SCORES)

Source	S.S.	d.f.	M.S.	F
Adjusted Means	392.6	3	130.88	4.5*
Within groups	3511.6	122	28.78	
Total	3904.2	125		

*p .01

Table X presents the results of the adjusted means. By inspection one can see where in the significance lies.

TABLE X

RESULTS OF ADJUSTING MEANS OF PREDICTED GAINS
(TIME AND PREDICTED GAIN SCORES)

Mode	$\bar{Y}'$
Programmed text	16.35
Lecture-workshop	16.79
Text	18.28
Lecture-demonstration	12.81

Table XI presents the results of the pre-and delayed posttest for those subjects returning the delayed posttest.

TABLE XI

RESULTS OF THE PRETEST AND DELAYED POSTTEST
(SUBJECTS RETURNING DELAYED POSTTEST)

	Pretest		Delayed Posttest		
Method	$\bar{X}$	S.D.	$\bar{Z}$	S.D.	N
Programmed text	5.9	5.9	15.2	11.4	22
Lecture-workshop	5.1	8.7	13.9	12.4	21
Textbook	9.9	8.9	15.6	11.0	22
Lecture-demonstration	8.3	9.6	16.3	12.1	21
All groups	7.3	8.7	15.2	11.5	

It should be noted that the size of the groups responding to the delayed posttest is smaller than the original group sizes. There were three attempts made to obtain the delayed posttests from the subjects.

Table XII presents the results of the analysis of variance of the pretest data of those subjects returning the delayed posttest.

TABLE XII

RESULTS OF ANALYSIS OF VARIANCE OF PRETEST DATA OF THOSE RETURNING DELAYED POSTTEST

Source	S.S.	d.f.	M.S.	F
Between groups	316.9	3	105.63	1.43 N.S.
Within groups	6054.4	82	73.83	
Total	6371.3	85		

As seen in Table XII, the differences among the means of the pretest data for those returning the delayed posttest was found to be not significant.

Table XIII presents the results of the analysis of variance on the delayed posttest data for the four instructional groups.

TABLE XIII

RESULTS OF ANALYSIS OF VARIANCE OF THE DELAYED POSTTEST DATA

Source	S.S.	D.F.	M.S.	F
Between groups	65.2	3	21.74	.16 N.S.
Within groups	11241.6	82	137.09	
Total	11306.8	85		

As seen in Table XIII, the differences among the means of the delayed posttest data was found to be not significant.

Table IV presents the results of the analysis of covariance of the pretest and delayed posttest data for those returning the delayed posttest.

TABLE XIV

RESULTS OF ANALYSIS OF COVARIANCE
ON THE PRETEST AND DELAYED POSTTEST

Source	S.S.	d.f.	M.S.	F
Adjusted means	63.4	3	21.14	.2 N.S.
Within groups	8528.9	81	105.30	
Total	8592.3	84		

As seen, the F ratio was not significant when the scores on the delayed posttest were adjusted by analysis of covariance for pretest differences.

When one compres the results of Table II, the analysis of variance on the pretest data for the four groups, with the results of Table XII, the analysis of variance on the pretest data of those that returned the delayed posttest, one finds that the results of Table II were significant, $p < .05$, while the results of Table XII yielded a non-significant F ratio. Therefore, it was of interest to investigate the possibility of a difference in the subpopulations of those returning the delayed posttest and those not returning the delayed posttests. Analysis of covariance was used.

For the three groups, programmed text, lecture-workshop, and textbook, no significant difference among the means of those returning the delayed posttest and those not returning the delayed

posttests was found.

For the lecture-demonstration group, the results of analysis of covariance showed a significant difference, $p < .01$, between the means. No significant difference was found between the pretest means using analysis of variance, but a significant difference, $p < .01$, was found between the posttest means using analysis of variance with the group returning the delayed posttest having a significantly greater mean than the group not returning the delayed posttest.

FINDINGS

From Table IV it may be seen that the F ratio for modes was not significant for achievement. From Table VII, it may be seen that the F ratio was significant beyond the .01 level for instructional times. The Scheffe test for multiple comparisons showed significant differences at the .01 level between the modes of programmed text and lecture-demonstration, text and lecture-demonstration, programmed text and text, and lecture-workshop and text, and at the .10 level for the comparison of lecture-workshop and lecture-demonstration as shown in Table VII. When predicted gain scores were adjusted for the amount of time spent for learning, the results presented in Table IX showed a significant difference at the .01 level of significance. The results of analysis of covariance in Table XIV show that the means of the four groups on delayed posttest data were not significantly different.

INTERPRETATION OF THE DATA

Since the F ratio for the instructional modes was not significant and the slopes of the four regression lines were about the same, it was concluded that there was no significant difference in the results of a test of achievement of the application of the rules of spatial analysis. As a result of the analysis of variance and the Scheffé, it was concluded that there was a significant difference in the time for the instructional modes. The practical value of the significant difference shown by the Scheffé test for the comparison of lecture-workshop and lecture-demonstration when just ten minutes separates the instructional times has yet to be demonstrated.

Adjustment of predicted learning gain with time yielded a significant difference and the researcher concluded that the increase in performance between groups was significantly different when the groups were adjusted for the amount of time spent for learning.

Adjustment of the delayed posttest scores with the pretest scores by analysis of covariance showed no significant difference among instructional modes. One group was found to have a significant difference in the sub-groups returning the delayed posttest versus those that did not return the delayed posttest. These results were felt not to have much bearing on the non-significant results.

CHAPTER V

SUMMARY AND CONCLUSIONS OF PHASE I, SECTION A

SUMMARY

Statement of the Problem

This study tested the following hypotheses:

(1) There are no significant differences in the results of a test of achievement requiring the application of the rules of Spatial Analysis of the Electrocardiogram among the groups of physicians using different modes of instruction: (a) textbook, (b) programmed textbook, (c) lecture-workshop, and (d) lecture-demonstration.

(2) There are no significant differences in instructional time to learn the rules of Spatial Analysis of the Electrocardiogram among the groups of physicians using different modes of instruction: (a) textbook, (b) programmed textbook, (c) lecture-workshop, and (d) lecture-demonstration.

(3) There are no significant differences among groups when the means of the predicted gain scores for achievement are adjusted for the amount of instructional time.

(4) There are no significant differences in the results of a delayed posttest of achievement requiring the application

of the rules of Spatial Analysis of the Electrocardiogram among the groups of physicians using the different modes of instruction: (a) textbook, (b) programmed text, (c) lecture workshop, and (d) lecture-demonstration.

Design of the Study

The subjects in this study were 148 participants of the 17th Annual West Coast Counties Regional Postgraduate Institute, March 2 and 3, 1967.

The subjects were assigned randomly to each of four instructional groups. The content of instruction was the same for each group. Subjects were pretested, given the treatment, and posttested. Instructional time was recorded. Delayed posttest data were collected starting three months after the instructional treatment.

The data, collected from the subjects in the form of answers to a test of plotting mean cardiac vectors in the horizontal and frontal planes from the recording of the standard 12-lead electrocardiogram and in individual instructional times.

Findings

No significant difference was found in the results of a test of achievement of the application of the rules of Spatial Analysis of the Electrocardiogram among the groups of physicians using the four modes of instruction. A significant difference was found among means of instructional times for the four modes and the increase in performance between groups was significantly different when the groups were adjusted

for the amount of time spent in learning. No significant difference was found among means of the delayed posttest of the subgroups of physicians returning the delayed posttest.

CONCLUSIONS

The conclusions were as follows:

(1) The authors accepted the hypothesis that there was no significant difference in the results of a test of achievement of the application of the rules of Spatial Analysis of the Electrocardiogram among groups of physicians using the different modes of instruction: (1) textbook, (2) programmed textbook, (3) lecture-worishop, and (4) lecture-demonstration.

(2) The authors rejected the hypothesis that there were no significant differences among means of instructional time to learn the rules of Spatial Analysis of the Electrocardiogram among the groups of physicians using different modes of instruction: (1) textbook, (2) programmed textbook, (3) lecture-demonstration.

(3) The authors rejected the hypothesis that there were no significant differences among means for achievement when the groups were adjusted for the amount of time spent for learning.

(4) The authors accepted - there are no significant differences in the results of a delayed posttest of achievement requir-

ing the application of the rules of Spatial Analysis of the Electrocardiogram.

CHAPTER VI

SUBJECTS, TECHNIQUES, AND PROCEDURES OF PHASE I, SECTION B

SUBJECTS

The subjects for Section B of Phase I of this study were a random sample of the 2452 physicians who had previously subscribed within the past five years to the "Basic Correspondence Course on Electrocardiography" with the University of Southern California School of Medicine, Postgraduate Division.

DESIGN OF THE STUDY

This portion of the experiment was designed to gather data on the effects of the texts, Spatial Analysis of the Electrocardiogram, and A Programmed Text on Spatial Analysis of the Electrocardiogram, on physician achievement in plotting mean P, QRS, and T vectors in electrocardiography when the textbooks were used as a correspondence course. It was hypothesized that (1) there are no significant differences in the results of a test of achievement requiring the application of the rules of Spatial Analysis of the Electrocardiogram among two groups of physicians using two different modes of instruction: (a) a textbook, Spatial Analysis of the Electrocardiogram, and (b) A Programmed Text on Spatial Analysis of the Electrocardiogram. (2) There are no

significant differences in instructional time to learn the rules of Spatial Analysis of the Electrocardiogram between the two groups of physicians using the different modes of instruction as a correspondence course: (a) textbook and (b) programmed textbook. (3) There are no significant differences between the two groups when the means of the predicted gain scores for achievement are adjusted for the amount of instructional time.

Statistical Technique

The data were gathered in the form of pretest, and posttest scores and instructional time from each subject.

Measurement of Achievement

Analysis of Covariance was used to test the significances of differences between the means of the posttest data by taking into account and adjusting initial differences in the groups using the pretest data. Also, the benefit of statistically matching the subjects was obtained.

Learning Time and Achievement

The technique developed for Section A of this report for Phase I of the study was also used for Section B of the study. This technique was developed as a result of the unreliability of gain scores.

The same computer program was used to regress the posttest scores on the pretest scores to find the regression line. Then the computer calculated the predicted posttest score for each individual, based upon the within group regression line, subtracted the actual pretest score from the predicted posttest score for each individual and

punched the reliable gain score in a specified field on the data card.

Analysis of covariance was used with the reliable gain scores as the dependent variable and the time score as the covariate. This program also gave the analysis of variance for the dependent and independent variables.

PROCEDURES

Subject Assignment to the Instructional Mode

The Postgraduate Division of the University of Southern California School of Medicine has a permanent card file listing the name and address of each physician who participated in an electrocardiography correspondence course. From this file of physician's names, who had participated in the correspondence course within the past five years, 2452 cards were pulled. These cards were alphabetized and numbered sequentially. By the use of a table of random numbers, 1000 physicians were assigned to one of the two instructional modes, the text or the programmed text.

Subject Solicitation

A letter by Dr. Manning was sent to each of the selected physicians asking for his participation in this correspondence course. The subject was told further that he would be able to keep the booklet and that his "participation would aid the Postgraduate Division in determining various advantages of the teaching method."[1] Enclosed

[1] Appendix H

with the initial letter was a stamped, self-addressed postcard for the physicians' response to our inquiry for his participation.

Subject Identification

Pretest. – When a postcard was received with an affirmative response, a packet was prepared for mailing to the subject. Each packet contained an addressed cover letter which explained the need for the pretest, gave instruction for completing the pretest and returning it in the self-addressed stamped envelope, explained that a booklet will then be sent, and that they were to complete a posttest after studying the booklet. They were also told that the purpose of this course was to test a method of instruction and not the individual.[2] The packet also contained the test booklet with the following items inside the front cover: (1) a P, QRS, and T orientation sheet (2) a pad of frontal and horizontal plane reference figures, (3) a salmon colored pretest answer sheet showing the subjects identification number written in the appropriate space, with an attached legal size stamped self-addressed envelope for the return of the completed pretest to the Postgraduate Division.[3]

Follow up on Pretest. – If a participant did not return the pretest within a month's time, a follow-up letter and a complete new packet was mailed to the subject.[4] At least two follow-up letters with a complete packet were sent to each of those that did not respond with a completed pretest.

[2]Appendix I
[3]Appendix D
[4]Appendix J

Instructional Treatments

The textbook was sent to those participants randomly selected for Group 5 and the programmed text was sent to those participants in Group 6. Upon return of the pretest answer sheet, the subject was mailed the appropriate text in a packet.

In the packet were the following items - (1) the cover letter, (2) the appropriate textbook,and (3) the test booklet with the P, QRS, and T orientation sheet, the horizontal and frontal plane reference figures pad, and a white posttest answer sheet with an attached self-addressed stamped envelope placed inside the front cover. The addressed cover letter explained to the subject that upon completion of his study of the booklet, he was to take the enclosed posttest without referring to the booklet. The subject was asked to indicate on the test sheet how long it took him to complete the textbook. Upon the completion of the test he was asked to mail the answer sheet in the enclosed self-addressed stamped envelope. It was again emphasized that the purpose was to test the method and not the individual physician.[5]

Follow up on the Posttest. - If a participant did not return the posttest within two month's time, a complete new test packet was mailed to the subject with an addressed cover letter asking the subject to please complete the posttest and to send it in the enclosed self-addressed stamped envelope. At least two follow-up letters with a complete text packet were sent to each of those that did not respond with a completed posttest.[6]

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[5]Appendix K
[6]Appendix L

Scoring

The investigator and the secretary for the project scored the tests using an answer key with squares cut out to reveal the correct answer when laid upon an answer sheet. Also, the identification number and the subject's answer to the individual test items were punched on data processing cards, which had been 100% verified and were used for scoring the tests by a computer test scoring program. The comparison of the machine scoring and the human scoring was used to check the reliability of the scoring.

The scores for each individual on the pretest, posttest, the instructional time, and the identification number were punched in data cards in the appropriate fields.[7] All data cards were given 100% verification. The regression program was used to obtain the reliable learning gains. These data automatically punched in the card by the computer. The analysis of covariance computer program was used to analyze the data.

SUMMARY

The subjects for this study were a random sample of physicians who had previously subscribed within the past five years to the "Basic Correspondence Course on Electrocardiography" with the Postgraduate Division, University of Southern California School of Medicine. The instructional modes of textbook and programmed textbook and the test were the same as developed for Phase I, Section A of this study.

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[7]Appendix M for raw data by identification number

The 500 subjects were randomly assigned to each of two instructional groups. The self-selected subjects for participation in the study were pretested, mailed the appropriate instructional treatment, and post-tested. Data were collected and treated statistically with analysis of covariance using a computer program.

CHAPTER VII

PRESENTATION OF THE DATA, FINDINGS AND INTERPRETATIONS OF PHASE I, SECTION B

PRESENTATION OF THE DATA

This portion of the study was to investigate the hypotheses:

1. There are no significant differences in the results of a test of achievement requiring the application of the rules of Spatial Analysis of the Electrocardiogram between two groups of physicians taught by a correspondence course using the instructional modes of either programmed text or textbook.
2. There are no significant differences in instructional time to learn the rules of Spatial Analysis of the Electrocardiogram among the groups of physicians using two different modes of instruction as a correspondence course: (1) textbook, and (2) programmed textbook.
3. There are no significant differences among the groups when the means of the predicted gain scores for achievement are adjusted for the amount of instructional time.

The population contained 2452 physicians. One thousand subjects were randomly assigned to one of two instructional modes. Table XV presents the data of the response of this sample from initial contact

to completed posttest.

TABLE XV

NUMBER OF PARTICIPANTS IN EACH PHASE OF THE CORRESPONDENCE COURSE

Stage of the Study	Textbook	Programmed Textbook
Initial contact	500	500
Affirmative response to participation	167	158
Received pretest materials	167	158
Returned pretest answer sheet	69	75
Completed text and returned posttest answer sheet	44	51

Table XVI presents the results of the pre-and posttest for the two instructional methods.

TABLE XVI

RESULTS OF PRE-AND POSTTESTS FOR CORRESPONDENCE COURSE

Method	Pretest $\bar{X}$	Pretest S.D.	Posttest $\bar{Y}$	Posttest S.D.	N
Text	14.80	8.49	26.82	5.20	44
Programmed Text	16.47	8.63	28.82	1.66	50

Table XVII presents the analysis of variance table on the pretest

TABLE XVII

ANALYSIS OF VARIANCE TABLE FOR PRETEST

Source	S.S.	d.f.	M.S.	F
Between groups	66.3	1	66.28	.90 N.S.
Within groups	6825.9	93	73.40	
Total	6892.2	94		

It can be seen in Table XVII the F ratio on the pretest was not significant.

Table XVIII presents the analysis of variance table on the post-test.

TABLE XVIII

ANALYSIS OF VARIANCE TABLE FOR POSTTEST

Source	S.S.	d.f.	M.S.	F
Between groups	95.0	1	94.99	6.80*
Within groups	1300.0	93	13.98	
Total	1395.0	94		

*$p < .05$

It can be seen in Table XVIII that the F ratio on the posttest was not significant, $p < .05$.

Table XIX presents the results of the Analysis of Covariance.

TABLE XIX

RESULTS OF ANALYSIS OF COVARIANCE

Source	S.S.	d.f.	M.S.	F
Adjusted means	72.7	1	72.71	5.8*
Within groups	1157.1	92	12.58	
Total	1229.8	93		*p < .05

It can be seen that the F ratio for the Analysis of Covariance is significant. The correlation coefficient within groups was .33 and the correlation coefficient total Y on X was .34. This indicates that the slopes of the two regression lines are the same. This shows the relationship between the Y variable, the posttest and the covariate X, and the pretest, are the same for both groups. The researchers concluded that the two groups were significantly different in achievement as the result of the two modes of instruction.

Of interest is the standard deviation for each of the groups on the posttest as seen in Table I. It appeared that the variability on the posttest of the programmed text group was much less than that of the text group. The null hypothesis $s_t^2 = s_{pt}^2$ was tested against the alternative hypothesis $s_t^2 \neq s_{pt}^2$ where s^2 is the variance of the group and the following subscripts t and pt are for text and programmed text respectively. The F test was used.[1]

[1] Allen L. Edwards, Experimental Design in Psychological Research (New York: Holt, Rinehart and Winston, 1960) p 105.

$F = \frac{s_t^2}{s^2} = 9.80$ with the degrees of freedom for the text = 43 and the degrees of freedom for the programmed text = 50. The difference between the variances was significant beyond the .01 level of confidence and the researchers rejected the null hypothesis of no difference between the variances of the two groups on the posttest and accepted the hypothesis that $s_t^2 > s_{pt}^2$ at $p < .01$.

Table XX presents the time in minutes for the two correspondence modes.

TABLE XX

TIME FOR THE TWO INSTRUCTIONAL MODES

Method	Mean	S.D.	N
Text	131.68	89.82	22
Programmed Text	144.69	123.66	32

Table XXI presents the results of analysis of variance for instructional times.

TABLE XXI

RESULTS OF ANALYSIS OF VARIANCE
FOR INSTRUCTIONAL TIMES

Source	S.S.	d.f.	M.S.	F
Between groups	2205.2	1	2205.19	.18 N.S
Within groups	643441.6	52	12373.88	
Total	645646.8	53		

As seen, the F ratio for the instructional times was not significant.

Table XXII presents the predicted gain scores.

TABLE XXII

PREDICTED GAIN SCORES

Method	Mean	S.D.	N
Text	12.36	7.69	22
Programmed text	11.87	6.97	32

Table XXIII presents the results of the analysis of covariance on instructional time and predicted gains.

TABLE XXIII

RESULTS OF ANALYSIS OF COVARIANCE ON TIME AND PREDICTED GAIN

Source	S.S.	d.f.	M.S.	F
Adjusted means	4.9	1	4.85	.1 N.S.
Within groups	2693.5	51	52.81	
Total	2698.4	52		

As shown by Table XXIII, the F ratio was not significant. The correlation coefficient within groups was .14, the correlation coefficient between means was -1.00, and the correlation coefficient total Y on X was .14.

The researchers conclude that the two groups were not significantly different when the predicted gain was adjusted for the instructional time for the two modes.

FINDINGS

From Table XV, the proportion of those accepting participation in the course from the original 500 inquiries for each mode was

.234 for the textbook and .216 for the programmed textbook group. The proportion of those returning pretest answer sheets of the 167 subjects, in the textbook group was .414 and for the 158 subjects in the programmed textbook group, it was .475. The proportion of those subjects returning a completed posttest answer sheet, from the textbook group, was .263 and from the programmed textbook group was .323. Of the 500 subjects contacted for each mode, the proportion of .088 on the textbook group and .102 for the programmed textbook completed the course with the posttest.

From Table XVII it was found that there was no significant difference between the groups when compared on the pretest.

From Table XVIII it can be seen that there was a significant difference between the groups when compared on the posttest.

From Table XIX it can be seen that the difference between the means of the two groups as a result of the different instructional modes was significant, $p < .05$.

It was found that the variance on the posttest for the programmed textbook instructional groups was significantly less than the variance on the posttest of the textbook instructional group.

From Table XXI, it was found that there was no significant difference between the two groups when compared on instructional time.

From Table XXIII, it can be seen there was no significant difference between the groups when the predicted gain was adjusted for the differences in instructional time.

CHAPTER VIII

SUMMARY AND CONCLUSIONS OF PHASE I, SECTION B

SUMMARY

Statement of the Problem

This portion of the study tested the hypothesis that (1) there are no significant differences in the results of a test of achievement requiring the application of the rules of Spatial Analysis of the Electrocardiogram among two groups of physicians using two different modes of instruction as a correspondence course: (a) a textbook, Spatial Analysis of the Electrocardiogram, and (b) a programmed textbook, A Programmed Text on Spatial Analysis of the Electrocardiogram, (2) there are no significant differences in instructional time to learn the rules of Spatial Analysis of the Electrocardiogram between the two groups of physicians using the different modes of instruction as correspondence in a correspondence course: (a) textbook, and (2) programmed textbook, (3) there are no significant differences between the two groups when the means of the predicted gain scores for achievement are adjusted for the amount of instructional time.

Design of the Study

The subjects for the correspondence study were a sample of physicians selected randomly from a population of 2452 having previous experience within the last five years with an electrocardiography

correspondence course from the Postgraduate Division. The population was self-selective in participation in this portion of the experiment.

The data, collected from the subjects in the form of answers on a pretest and a posttest of plotting mean cardiac vectors in the horizontal and frontal planes from the recording of the standard 12-lead electrocardiogram and instructional time was analyzed by the analysis of covariance.

INTERPRETATION OF THE DATA

Since the F ratio from the analysis of covariance table was significant, it was concluded that there was a significant difference in the results of a test of achievement requiring the application of the rules of Spatial Analysis between the two groups as a result of the two instructional modes. It was further concluded that for this population, the programmed text mode of instruction resulted in significantly less variance on the pretest than did the textbook mode of i   truction.

Findings

A significant difference was found in the resu s of a test of achievement of the application of the rules of Spatial Analysis of the Electrocardiogram among the two groups of physicians using the two methods of instruction $p < .05$. A significant difference was found in the variance of the two groups on the posttest with the variance on the posttest of the textbook group significantly greater than the variance on the posttest of the programmed textbook group beyond the .01 level of significance.

No significant difference was found between the two groups when compared on instructional time. No significant difference was found between the two groups when compared with the predicted gain scores adjusted for differences in instructional time.

CONCLUSION

The conclusions were as follows:

(1) The authors rejected the hypothesis that there was no significant difference in the results of a test of achievement of the application of the rules of Spatial Analysis of the Electrocardiogram among groups of physicians using the two different modes of instruction: (a) a textbook, Spatial Analysis of the Electrocardiogram, and (b) a programmed textbook, A Programmed Text on Spatial Analysis of the Electrocardiogram.

(2) The authors further conluded that the variance on the posttest of the textbook was significantly greater than the variance on the posttest of the programmed textbook group beyond the .01 level of significance.

(3) The authors accepted the hypothesis that there was no significant difference in instructional time to learn the rules of Spatial Analysis of the Electrocardiogram between two groups of physicians using the different modes of instruction as correspondence courses: (a) textbook, and (b) programmed textbook.

(4) The authors accepted the hypothesis that there was no significant difference between the two groups when the means of the predicted

gain scores for achievement were adjusted for the amount of instructional time.

CHAPTER IX

SUBJECTS, TECHNIQUES AND PROCEDURES OF PHASE I, SECTION C

SUBJECTS

The 60 subjects for Phase I, Section C, of this study were participants in the Postgraduate Course, "Spatial Analysis of the Electrocardiogram," which took place January 18, 1968 in Las Vegas, Nevada.

DESIGN OF THE STUDY

The number of participants in the course limited the modes of instruction to three.

The experiment was designed to gather data on the effects of three modes of instruction on physician achievement in plotting mean P, QRS, and T vectors in electrocardiography. It was hypothesized that:

(1) The results of a test of clinical skill in plotting mean cardiac vectors would show scores not significantly different among the three modes of instruction: (a) lecture-workshop, (b) lecture-demonstration, and (c) <u>A Programmed Text on Spatial Analysis of the Electrocardiogram</u>.

(2) The differences in mean instructional times of the three modes are not significantly different.

(3) There are no significant differences among the means for

predicted gain when adjusted for the amount of instructional time.

Statistical Techniques

Measurement of Achievement. - The data were gathered in the form of pretest, posttest scores and instructional time for each subject. Analysis of covariance was used to test the significance of differences between the means of the posttest data by taking into account and adjusting for initial differences in the groups on the pretest. The analysis of covariance also statistically matches the subjects for the experimenter.

Learning Time and Achievement. - The technique developed for Section A of this report for Phase I of the study was also used for Section C of the study. This technique was developed as a result of the unreliability of gain scores.

The same computer program was used to regress the posttest scores on the pretest scores to find the regression line. Then the computer calculated the predicted posttest score for each individual based upon the within group regression line, subtracted the actual pretest score from the predicted posttest score for each individual and punched in a specified field on the data card the reliable gain score.

Analysis of covariance was used with the reliable gain scores as the dependent variable and the time score as the covariate. This program also gave the analysis of variance for the dependent and independent variables.

Experimental Variables

Instructional Variables. - The subjects each were randomly

assigned to one of three instructional groups using a table of random numbers. Each group was randomly assigned to an instructional mode in the same manner.

The group assigned to the programmed textbook was taught entirely by that mode.

The lecture-workshop and lecture-demonstration groups were taught by the same three instructors who had written both text modes.

PROCEDURES

Instructional and Test Materials

The same instructional materials developed for Phase I, Section A of the experiment were used with the exception of the textbook.[1]

The test was the same as used for Section A.[2]

Preparation of Packets for the Subjects

Each subject was given a four digit identification number. The first digit signified the treatment group one to three. The last three digits signified the numerical position of the subject's name on the original registration list used for the randomization of the subjects to the three treatment groups.

The packets containing the materials used in this portion of the experiment were prepared before the date of this portion of the study. Each packet contained the following items: (1) questionaire sheet to be

[1]Appendix A
[2]Appendix C

filled in by the subject, (2) P, QRS and T orientation sheet, (3) pad of frontal and horizontal plane reference figures, (4) test booklet with a salmon colored pretest answer sheet inserted inside the back cover, (5) a legal size envelope enclosing a buff colored posttest answer sheet, only for the lecture-demonstration and lecture-workshop, and (6) for the lecture-demonstration packets only a stapled group of seven ECG tracings.[3] The posttest answer sheets and envelopes for the programmed text group were in a file for distribution after each subject completed the text.

The following items were prenumbered with each subject's identification number: (1) the packet, (2) the information sheet, (3) the pretest answer sheet, (4) the legal size envelope, (5) the inserted posttest answer sheet in the legal size envelope, and (6) the institute name badge which was given to the subject upon registration.

Lecture-demonstration and Lecture-workshop Treatments

The instructional area for the first portion of both the lecture-workshop and the lecture-demonstration was arranged according to the recommendations in Audiovisual Projection.[4]

A matte screen with an image width of 10 feet was chosen in accordance with the recommendations for the screen size. A Kodak Carousel 2" x 2" slide projector, Model 800 with an Ektanar 4" x 6" zoom lens was used to project the slides. The projected image filled

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[3]Appendix D

[4]Eastman Kodak Company, Audiovisual Projection, (Rochester, N.Y.: Eastman Kodak Company, Motion Picture and Educational Markets Division, Pamphlet No. S-3), pp. 5-8.

the screen area. The projected images were black and white line drawings and did not necessitate complete darkening of the room. There was sufficient illumination for notetaking during the lectures.

Pretreatment Preparation

All of the participants met in the same meeting room for the introduction. The packets were distributed numerically in order and a pencil placed by each packet before the subjects were noted. The packets for the lecture-demonstration accompanied the front area of the trapezoidal area of seating. Behind this area, the packets for the lecture-demonstration were placed. In the back area of the trapezoid were placed the packets for the programmed text group.

After the subjects had located the packet with the number corresponding to the identification number c. his registration badge, the subjects were seated. Phil R. Manning, M.D. gave the introduction and identified the contents c s. The subjects were then told that the directions, superior, inferior, etc., in the test booklet pertained to the figures on the reference pad. A transparency of the P wave, QRS complex and the T wave orientation sheet was shown by overhead projection and the ECG tracings were explained.

The programmed instruction group left for another room to take the pretest. The lecture-demonstration group and the lecture-workshop group remained in the same room.

Pretest. – The contents of the packets were identified by the proctor. Each subject was asked to fill out the questionaire after he had finished

the pretest. The subjects were asked to open the their test booklets to the first page, the directions. After these were read aloud, questions were asked for. There were none. Since the subjects were to plot P, QRS, or T vectors, they were warned to be certain as to which wave the question referred. They were also told not to be discouraged if they could not answer any of the test items. The proctor noted the time and the subjects were told to begin. The directions indicated that each subject had thirty minutes to complete the test. They were advised when fifteen minutes of the time remained. At the end of thirty minutes they were requested to stop and to place the text booklet back in the large packet. At the end of the test period, those remaining answer sheets were collected. Those that completed the test early were allowed to leave for coffee. Care was taken to receive a pretest answer sheet from each subject.

Experimental Treatment for the Combined Groups; Lecture-workshop and Lec ure-demonstration. - For the combined groups comprising the subjects for the lecture-demonstration and lecture-workshop, Irwin Hoffman, M.D. lectured from Chapter I, Section I through Part 9 covering unipolar leads, axes and fields, using fifty illustrations. This lecture time was forty-two minutes.

The lecture-workshop group was then taken to another room to complete their instruction. The lecture-demonstration group remained seated.

Lecture-demonstration Treatment. - For the remainder of the instruction, James V. Dooley, M.D., lectured from Chapter I,

Section I, Part 10 through the end of the Section II covering the frontal plane leads and mean frontal QRS vector using forty-five illustrations and through Section III, mean horizontal QRS vector and the summary, using thirty-two illustrations. This lecture time was thirty minutes.

Lecture-workshop Treatment. – For the completion of the instruction, Julien H. Isaacs, M.D. lectured from Section I, Part 10 through Section II, Example 1 covering frontal plane leads and mean frontal QRS vectors using twenty-eight illustrations and in Section III covering the mean horizontal QRS vector and summary, using eighteen illustrations. This instructional time took eleven minutes. The workshop portion of the lecture used the examples from Section II and Section III not covered by the lecture. The example was projected on the screen and the subjects practiced plotting the appropriate vector. The two instructors, Dr. Julien Isaacs and Dr. Irwin Hoffman circulated among the subjects answering questions. This instructional time was sixty-four minutes.

Programmed Text Treatment. – The programmed textbooks w distributed, five to a table before the instructional session began. After the subjects were seated, they were told to take a textbook from the center of the table. Directions for the programmed textbook were read aloud. The proctor told the subjects to study the text as they normally would. Upon completing the text, they were asked to bring the text to the proctor's desk and receive the posttest. Any questions were answered. The proctor wrote down the time, on the provided list, and told the subjects to begin studying.

During this study period, the subjects were free to smoke, go out for coffee that was provided, take a break for whatever was deemed necessary for the Las Vegas environment. Other than the group setting, no attempt was made to control the study habits of the subjects. During this period the starting time was written opposite each subject's name in the space provided.

Having completed his studying, the subject brought his text forward. The proctor noted the time the text was handed in.

Posttest, -Lecture-demonstration and Lecture-workshop Groups. - Upon completion of the instruction, the subjects were asked to take out the legal size envelope and take out the buff colored answer sheet and retake the test. The time was noted by the proctor and the subjects were told to begin. They were advised when fifteen minutes of the thirty minute test period remained. At the end of thirty minutes, they were requested to stop and place the test booklet back in the large packet. Care was taken to insure that an answer sheet was collected from each subject. The subject was then dismissed.

Posttest - Programmed Text Group. - After receiving the text from the subject and recording the time in the space provided on the subject list, the proctor gave to the subject the envelope containing the posttest answer sheet. The subject was told to take no more than thirty minutes for the posttest. When the subject completed the posttest, he turned in the answer sheet. The time was written down in the appropriate space on the list, and the subject was dismissed. Care was taken to insure that an answer sheet was received from each subject and no

subject went over thirty minutes for the test period.

Scoring

Data cards which had been 100% verified were punched and a key data card was used to score the tests. Also, a computer test scoring program was used to score the tests. The comparison of the machine scoring and the human scoring was used to check the reliability of the scoring. The scores for each individual on the pretest, posttest, the instructional time, and the identification number was punched in data cards in the appropriate fields.[5] All data cards were given 100% verification. The regression program was used to obtain the reliable learning gains. These data were automatically punched in the card by the computer. The analysis of covariance computer program was used to analyze the data.

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[5]Appendix N for raw data by identification number

SUMMARY

The subjects for this Section C of the Phase I of the study were participants in the University of Southern California School of Medicine Postgraduate Division program "Spatial Analysis of the Electrocardiogram," Las Vegas, January 18, 1968. The three instructional modes, the lecture-workshop, the lecture-demonstration, the programmed textbook and the test developed for Section A of Phase I of this study were used. The subjects were randomly assigned to each of the three instructional groups.

The subjects were pretested, given the appropriate instructional treatment, instructional treatment time, and posttested. Standard controls of light intensity, noise level, and duration of the tests were followed. The data were collected and treated statistically with regression analysis and analysis of covariance using computer programs.

CHAPTER X

PRESENTATION OF THE DATA, FINDINGS AND INTERPRETATION

PRESENTATION OF THE DATA

This study, Section C of Phase I, was to investigate the following hypotheses:

1. The results of a test of clinical skill in plotting mean cardiac vectors would show scores not significantly different among the three modes of instruction of lecture-workshop, lecture-demonstration, and programmed text.
2. The differences in mean instructional times of the three instructional modes are not significantly different.
3. There are no significant differences among the means of the predicted gains for the three groups when the means are adjusted for the amont of time spent for learning.

Table XXIV presents the results of the pre-and posttest.

TABLE XXIV

RESULTS OF PRE-AND POSTTEST

Method	Pretest $\bar{X}$	Pretest S.D.	Posttest $\bar{Y}$	Posttest S.D.	N
Lecture-demonstration	17.3	9.6	25.4	3.8	18
Programmed text	18.4	9.5	26.1	5.1	22
Lecture-workshop	12.6	9.5	23.5	6.6	20

Table XXV presents the results of the analysis of variance on the pretest.

TABLE XXV

RESULTS OF ANALYSIS OF VARIANCE TABLE ON THE PRETEST

Source	S.S.	d.f.	M.S.	F
Between groups	389.7	2	194.87	2.15 N.S.
Within groups	5171.7	57	90.73	
Total	5561.4	59		

Table XXVI presents the results of the anlysis of variance on the posttest.

TABLE XXVI

ANALYSIS OF VARIANCE TABLE ON THE POSTTEST

Source	S.S.	d.f.	M.S.	F
Between groups	79.2	2	39.58	1.35 N.S.
Within groups	1776.8	57	20.22	
Total	1745.0	59		

It can be seen that the F ratio is not significant in Table XXVI.

Table XXVII presents the results of the analysis of covariance on the pre-and posttest.

TABLE XXVII

ANALYSIS OF COVARIANCE TABLE
(ACHIEVEMENT)

Source	S.S.	d.f.	M.S.	F
Adjusted means	8.0	2	3.98	.2 N.S.
Within groups	1178.2	56	21.04	
Total	1186.2	58		

It can be seen the analysis of covariance F ratio for achievement is not significant.

Table XXVIII presents the results of the instructional time.

TABLE XXVIII

INSTRUCTIONAL TIME

Method	Mean	S.D.	N
Lecture-demonstration	72.00	.0	18
Programmed textbook	77.7	24.9	22
Lecture-workshop	118.00	.0	20

Table XXIX presents the results of the analysis of variance on the instructional times.

TABLE XXIX

ANALYSIS OF VARIANCE TABLE FOR INSTRUCTIONAL TIMES

Source	S.S.	d.f.	M.S.	F
Between groups	22677.0	2	11838.52	51.80*
Within groups	13026.4	57	228.53	
Total	36703.4	59	*p	.01

As can be seen from Table XXIX, the differences between the means for instructional times was significant beyond the .01 level.

Table XXX presents the results of Scheffé's Test for Multiple Comparisons.

TABLE XXX

RESULTS OF THE SCHEFFÉ TEST ON INSTRUCTIONAL TIME

For the following comparisons, the differences between means was significant beyond the .01 level,

1. Lecture-workshop versus the Lecture-demonstration.
2. Lecture-workshop versus the programmed textbook.

As shown in Table XXX, the Lecture-workshop took significantly more time for instruction than the other two modes. The difference between the instructional time means for the Lecture-workshop and the Programmed textbook was found to be not significant.

As previously stated in Section A of Phase 1, the Scheffé Test is quite conservative and Scheffé suggests that one may consider the .10 level of significance rather than the .05 level of significance as the significance level for comparisons.

Table XXXI shows the results of the within group regression analysis to obtain the predicted gain scores for each group.

TABLE XXXI

PREDICTED GAIN SCORES

Method	Mean	S.D.	N
Lecture-demonstration	7.78	6.31	18
Programmed text	7.05	6.33	22
Lecture-workshop	10.85	6.52	20

The results of the analysis of covariance using the reliable gain scores as the dependent variable and learning time as the covariate is presented in Table XXXII

TABLE XXXII

RESULTS OF ANALYSIS OF COVARIANCE TABLE
(TIME AND PREDICTED GAIN SCORES)

Source	S.S.	d.f.	M.S.	F	
Adjusted means	97.3	2	48.67	1.4	N.S.
Within groups	1906.5	56	34.05		
Total	2003.9	58			

As noteu the F ratio is not significant.

INTERPRETATION OF THE DATA

Since the F ratio for instructional modes was not significant, it was concluded that there was no significant difference among groups in the results of a test of achievement of the application of the rules of Spatial Analysis when compared on achievement. As a result of the analysis of variance on the instructional times, it was concluded that there was a significant difference in the means of the instructional modes beyond the .01 level of confidence. Further analysis using the Scheffé's Test for Multiple Comparisons showed that the Lecture-workshop took significantly more time than either the Lecture-demonstration of the Programmed text. When the reliable gain scores were adjusted for the amount of learning time the results of analysis of covariance showed a non-significant F ratio.

CHAPTER XI

SUMMARY AND CONCLUSIONS OF PHASE I, SECTION C

SUMMARY

Statement of the Problem

Section C of Phase I of this Study tested the following hypotheses:

1. There are no significant differences in the results of a test of clinical skill in plotting mean cardiac vectors requiring the applications of the rules of Spatial Analysis of the Electrocardiogram among the groups of physicians using the three modes of instruction: (1) Lecture-workshop, (2) Lecture-demonstration, and (3) a programmed textbook A Programmed Text on Spatial Analysis of the Electrocardiogram.
2. There are no significant differences in instructional time to learn the rules of Spatial Analysis of the Electrocardiogram among the three groups of physicians using the three different modes of instruction.
3. There are no significant differences among the means of predicted gain scores when adjusted for the amount of time spent for learning for the three group of physicians.

Design of the Study

The subjects for Section C of Phase I of this study were participants in the Postgraduate Course, "Spatial Analysis of the Electrocardiogram," January 18, 1968.

The subjects were assigned randomly to each of three instructional groups. The content of instruction was the same for each group. The subjects were pretested, given the treatment, and posttested. Instructional time was recorded.

The data were collected from the subjects in the form of answers to the two tests of plotting mean cardiac vectors in the horizontal and frontal planes from the recording of the standard 12-lead electrocardiogram and in individual instructional or group instructional time.

Findings

No significant difference was found in the results of a test of achievement of the application of the rules of Spatial Analysis of the Electrocardiogram among the groups of physicians using the three modes of instruction. A significant difference was found among means of instructional times for the three modes. The differences between the means of the reliable scores for the groups when adjusted for the learning time was found to be not significant.

CONCLUSIONS

The conclusions were as follows:

1. The authors accepted the hypothesis that there are no significant differences in the results of a test of clinical skill in

plotting mean cardiac vectors requiring the application of the rules of Spatial Analysis of the Electrocardiogram among the groups of physicians using the three modes of instruction: (1) lecture-workshop, (2) lecture-demonstration, and (3) a programmed textbook.

2. The authors rejected the hypothesis that there was no significant difference among the means of instructional time to learn the rules of Spatial Analysis of the Electrocardiogram among the three groups of physicians using the different modes of instruction: (1) lecture-workshop, (2) lecture-demonstration, and (3) a programmed textbook.
3. The authors accepted the hypothesis that there was no significant difference among the means of the predicted gain scores when adjusted for the amount of time spent for learning for the three groups of physicians.

CHAPTER XII

SUBJECTS, TECHNIQUES, AND PROCEDURES OF PHASE I, SECTION D

SUBJECTS

The subjects for Section D of Phase I of this study were freshman medical students at the University of Southern California School of Medicine. The study occurred February 19, 1968.

DESIGN OF THE STUDY

The experiment was designed to gather data on the effects of two modes of instruction on freshman medical student achievement in plotting mean P, QRS, and T vectors in electrocardiography. It was hypothesized:

1. There are no significant differences in the results of a test of achievement requiring the application of the rules of Spatial Analysis of the Electrocardiogram between two groups of freshman medical students using different modes of instruction: textbook and programmed textbook.
2. There are no significant differences in instructional time to learn the rules of Spatial Analysis of the Electrocardiogram between two groups of freshman medical students using the two modes of instruction: textbook and programmed textbook.

3. There are no significant differences between the means of the predicted gains for the two groups when adjusted for the amount of time spent for learning.

The data were gathered in the form of pretest scores, posttest scores and instructional time for each subject.[1]

Statistical Techniques

Measurement of achievement. – Analysis of covariance was used to test the significance of the differences between the means of the posttest data by taking into account and adjusting for initial differences in the groups on the pretest. Analysis of covariance also statistically matches the subjects for the experimenter, obtaining the desired benefits of matching. The Analysis of Covariance program also gives the analysis of variance for the independent and dependent variables.

Learning time and achievement. – The technique used in section A of the report for Phase I of the study was applied to the data.[2] This technique was developed as a result of the unreliability of gain scores. The computer program regressed the posttest scores on the pretest scores to find the regression line, calculated the predicted posttest score for each individual based upon the within group regression line, subtracted the actual pretest score from the predicted posttest score for each individual and punched the reliable gain score in a specified

[1]Appendix O for raw data by Identification number
[2]Page 11 Phase I, Section A

field on the data card. Analysis of covariance was used with the reliable gain scores as the dependent variable and the time score as the independent variable. The program also gives the analysis of variance for the dependent and independent variables.

Experimental Variables.

Instructional variables. - The subjects each were randomly assigned to one of two instructional groups using a table of random numbers. Each group was randomly assigned to an instructional mode in the same manner.

PROCEDURES

Instructional and Test Materials

The textbook and programmed textbook developed for Section A of Phase I of this study were used for this section of the study.[3] The test was the same as used in Section A.[4]

Preparation of Materials for Subjects

Each subject was given a four digit identification number. The first digit signified the treatment group, one and two. The last three digits signified the numerical position of the subject's name on the original student roster used for the randomization of the subjects to the two instructional groups.

A pretest booklet was prepared with a P, QRS, and T orientation sheet and a pad of frontal and horizontal plane reference figures

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[3] Appendixes A and B

[4] Appendix C

contained in ..le the front cove.. A salmon colored pretest answer sheet pren..bered with a subjects identification number, was clipped to the outside of the outside of the test booklet.[5]

Lists of the subjects with their identification number were prepared. Posttest answer sheets were numbered and arranged into the two groups by treatment number.

Pretreatment Preparation

While the subjects were attending a lecture in McKibben Hall, Room 156, the lists of the subjects with their identification number were placed on bulletin boards outside the main entrance to the lecture hall. The pretest booklets were separated into two piles; one for group one and one for group two. The textbooks were placed out of reach behind the secretaries assisting in the distribution of the materials. Each secretary had a list which contained for each subject his identification number and columns for pretest beginning time, text beginning time, text ending time, and posttest ending time, pretest score, posttest score and instructional time.

Pretest Instructions

The subjects were seated in the lecture hall at the completion of a lecture. Dr. Phil R. Manning gave the introduction and projected a transparency of the P wave, QRS complex and T wave orientation sheet and explained the ECG tracings. It was explained that this experi-

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[5] Appendix D

ment was to test two instructional methods and that the subjects were the means by which the two methods were to be tested.

The items which the subjects would receive with the pretest were shown and explained. They were told to find their name and identification number on the lists posted outside the room, to go to the desk and ask for the pretest materials which corresponded to their identification number. They were advised that the directions allowed only thirty minutes for completion of the test, to time themselves, and not to be discouraged if they could not answer the questions.

The subjects were directed to take all materials to their study carrel and use them there. Upon completion of the pretest they were to return to the treatment materials table, turn in the pretest booklet and answer sheet and receive the appropriate text. They were asked to study as they normally would. Upon finishing the text they were to return to the table, obtain another test booklet and a posttest answer sheet. Again, they were to time themselves, allowing no more than thirty minutes for the test.

Pretest

Each subject was given his pretest upon telling the secretary his identification number. For each subject, the time at which the pretest was handed to him was recorded. The subjects took their pretests to their individual study areas to take the test.

Experimental Treatment

When the subject returned the pretest materials, he was given

the appropriate text. The time for each individual was recorded in the appropriate space. The students were allowed to use the P, QRS, and T orientation sheet and the pad of reference figures during the instructional period. A proctor circulated among the study rooms. Students were allowed to smoke, get up, move about and to study as they normally would with the exception that they were required to study alone. No direct attempt was made to control the noise level. The rooms were quiet and the subjects studious.

Posttest

When a subject returned the textbook, the time was recorded in the appropriate column. The subject was given a test booklet and his prenumbered posttest answer sheet, and again told to not take more than thirty minutes for the posttest. The proctor circulated and stopped those subjects that were attempting to take more than thirty minutes on the posttest.

Scoring

Data cards, 100% verified, were punched and a punched key data card was used to score the tests. In addition, a computer test scoring program was used to provide a reliability check of the scoring. The instructional time was computed twice with a week separating computations of the data and with a different subject order as a reliability check on the instructional time calculations.

The identification number, the scores for each individual for the pretest, posttest, and the instructional time for each subject were

punched in the appropriate fields of data cards. All data cards were 100% verified. The regression program was used to obtain the reliable learning gains which were punched in the appropriate field in the subject's data card. The data were statistically analyzed by analysis of covariance.

SUMMARY

The subjects for this Section D of the Phase I of the study were freshman medical students from the University of Southern California School of Medicine. Two instructional modes were used; the programmed text and the textbook. Each of the subjects were randomly assigned to one of two instructional modes. The data were collected and treated statistically with the appropriate statistical techniques.

CHAPTER XIII

PRESENTATION OF THE DATA, FINDINGS AND INTERPRETATIONS PHASE I, SECTION D

PRESENTATION OF THE DATA

This study, Section D of Phase I, was to investigate the following hypotheses:

1. The results of a test of clinical skill in plotting mean cardiac vectors would show scores not significantly different between the two modes of instruction; the programmed textbook and the textbook.
2. The differences in mean instructional times of the instructional modes are not significantly different.
3. There are no significant differences between the means of the predicted gains for the two when the means are adjusted for the amount of time spent for learning.

Table XXXIII presents the results of the pretest and posttest.

TABLE XXXIII

RESULTS OF PRETEST AND POSTTEST

Method	Pretest $\overline{X}$	Pretest S.D.	Posttest $\overline{Y}$	Posttest S.D.	N
Programmed text	1.9	4.0	27.6	4.1	31
Textbook	2.1	4.4	26.3	4.2	37

The absences of two subjects and the lack of following directions by four other subjects resulted in the difference in the size of the two groups.

Table XXXIV presents the results of the analysis of variance on the pretest.

TABLE XXXIV

RESULTS OF ANALYSIS OF VARIANCE ON THE PRETEST

Source	S.S.	d.f.	M.S.	F
Between groups	.7	1	.74	.04 N.S.
Within groups	1154.2	66	17.49	
Total	1155.0	67		

As shown in Table XXXIV, the analysis of variance on the pretest disclosed a non-significant F ratio.

Table XXXV presents the results of the analysis of variance on the posttest.

TABLE XXXV

RESULTS OF ANALYSIS OF VARIANCE ON THE POSTTEST

Source	S.S.	d.f.	M.S.	F
Between groups	27.6	1	27.55	1.63 N.S.
Within groups	1119.0	66	16.95	
Total	1146.5	67		

As shown in Table XXXV, the F ratio for the significance of difference on the posttest was not significant.

Table XXXVI presents the results of the analysis of covariance of the pretest and posttest scores.

TABLE XXXVI

RESULTS OF THE ANALYSIS OF COVARIANCE ON THE PRETEST AND POSTTEST SCORES

Source	S.S.	d.f.	M.S.	F
Adjusted means	27.6	1	27.56	1.6 N.S.
Within groups	1119.0	65	17.21	
Total	1146.5	66		

As seen, the F raio for the analysis of covariance was not significant. The experimenters concluded that there was no significant difference between the two modes of instruction when compared on achievement.

Table XXXVII presents the results of the instructional times for the two modes.

TABLE XXXVII

RESULTS OF INSTRUCTIONAL TIME FOR BOTH MODES

Mode	Mean	Standard Deviation	N
Programmed text	81.7	15.2	31
Textbook	66.1	18.0	37

Table XXXVIII presents the results of the analysis of variance table comparing instructional times for the two modes.

TABLE XXXVIII

ANALYSIS OF VARIANCE TABLE
COMPARING INSTRUCTIONAL TIMES

Source	S.S.	d.f.	M.S.	F
Between groups	4074.6	1	4074.59	14.46*
Within groups	18597.1	66	281.77	
Total	22671.7	67		*p .01

As shown by Table XXXVIII, the differences in mean instructional times was significant beyond the .01 level and it was concluded there was a significant difference in instructional time for the two methods.

Table XXXIX presents the results of the within group regression analysis to determine the predicted gains for each instructional group.

TABLE XXXIX

PREDICTED GAIN SCORES

Method	Mean	S.D.	N
Programmed text	24.13	3.95	31
Textbook	23.92	4.37	37

Table XL presents the results of analysis of covariance with the predicted gain scores for each group adjusted for the amount of time spent for learning.

TABLE XL

RESULTS OF ANALYSIS OF COVARIANCE TABLE
(PREDICTED GAIN SCORES AND TIME)

Source	S.S.	d.f.	M.S.	F
Adjusted means	2.8	1	2.83	.2 N.S.
Within groups	1120.5	65	17.24	
Total	1123.3	66		

As shown by Table XL, the differences between the means of the predicted gain scores are not significantly different when adjusted for the difference in instructional time.

FINDINGS

From Table XXXVI, it may be seen that the F ratio for modes was not significant for achievement. From Table XXXVIII, it may be seen that the F ratio was significant beyond the .01 level of confidence for the difference in instructional times and the instructional time for the textbook was significantly less than that for the programmed textbook. From Table XL, it may be seen that the F ratio was not

significant when the predicted gain scores were adjusted for the amount of time spent for learning.

INTERPRETATION OF THE DATA

Since the F ratio for the instructional modes was not significant for this population, it was concluded there was no significant difference in the results of a test of achievement of the application of the rules of spatial analysis.

The F ratio for the differences in time for the instructional modes was significant beyond the .01 level of significance and it was concluded that the textbook was more efficient for learning than the programmed textbook when compared on instructional time.

When the means of the predicted gains for the two groups were adjusted for the amount of time spent for learning, it was found the F ratio was not significant and it was concluded there are no significant differences between the means of the predicted gain scores when adjusted for the amount of time spent for learning.

CHAPTER XIV

COST ANALYSIS - PHASE I

TABLE XLI

DEVELOPMENT EXPENSE FOR CONTENT

Services and supplies	$ 4,722.01
Salaries	5,291.25
Travel	$ 315.20
	$ 10,328.46
Instructors' Salaries for Development	$ 4,620.00

TABLE XLII

TEXTBOOK EXPENSE WITH CONTENT DEVELOPMENT EXPENSE

	N	Printing Cost	Total Cost	Cost per Student*
Initial Printing	300	$ 1,196.70	$ 11,525.16	$ 38.42
Projection for a larger population	500	1,304.00	11,632.46	23.26
	1,000	1,628.00	11,956.46	11.96
	2,500	2,477.00	12,805.46	5.12
	5,000	3,713.00	14,051.46	2.81
	10,000	6,325.00	16,653.46	1.66
	20,000	10,695.00	21,023.46	1.05

*Office overhead for course not included

TABLE XLIII

TEXTBOOK EXPENSE WITH CONTENT DEVELOPMENT AND INSTRUCTORS' COSTS

	N	Total Cost	Cost per Student*
Initial Printing	300	$ 16,145.16	$ 53.82
Projection for a larger population	500	16,252.46	32.50
	1,000	16,576.46	16.58
	2,500	17,425.46	6.57
	5,000	18,661.46	3.73
	10,000	21,273.46	2.13
	20,000	25,643.46	1.28

*Office overhead for course not included

TABLE XLIV

PROGRAMMED TEXTBOOK EXPENSE WITH CONTENT DEVELOPMENT COSTS

	N	Printing Cost	Total Cost	Cost per Student*
Initial Printing	300	$ 1,712.75	$ 12,041.21	$ 40.14
Projection for a larger population	500	2,732.00	13,060.46	26.12
	1,000	3,221.00	13,549.46	13.55
	2,500	4,084.00	14,412.46	5.76
	5,000	6,242.00	16,570.46	3.31
	10,000	10,169.00	20,497.46	2.05
	20,000	16,965.00	27,293.46	1.36

*Office overhead for course not included

TABLE XLV

PROGRAMMED TEXTBOOK EXPENSE
WITH CONTENT DEVELOPMENT AND INSTRUCTORS' COSTS

	N	Total Cost	Cost per Student*
Initial Printing	300	$ 16,661.21	$ 55.54
Projection for a larger population	500	17,680.46	35.36
	1,000	18,169.46	18.17
	2,500	19,032.46	7.61
	5,000	21,190.46	4.24
	10,000	25,117.46	2.51
	20,000	31,913.41	1.60

*Office overhead for course not included

TABLE XLVI

LECTURE - WORKSHOP EXPENSE
FOR MINIMUM COURSE SIZE

A.	Development expense with instructors' preparation costs -	$ 14,958.46
B.	Development expense for the course	$ 10,328.46
C.	Instructor salary for three instructors per course in the Los Angeles area for one-half day	$ 150.00
D.	Instructor salary for three instructors per course outside of the Los Angeles area, for a full day,	$ 300.00

The minimum number of students per course is forty-five.

TABLE XLVI – continued

Number of Courses	Number of Students	COST PER STUDENT* (A+C)/N	(A+D)/N	(B+C)/N	(B+D)/N
1	45	$ 335.74	$ 339.08	$ 232.85	$ 236.19
2	90	169.53	172.87	118.09	121.42
3	135	114.13	117.47	79.84	83.17
4	180	86.43	89.77	60.71	64.05
5	225	69.81	73.15	49.25	52.57
6	270	58.74	62.07	41.59	44.92
7	315	50.82	54.15	36.12	39.46
8	360	44.88	48.22	32.23	35.51
9	405	40.27	43.60	28.83	32.17
10	450	36.57	39.91	26.29	29.61

*Office overhead for course not included

TABLE XLVII

LECTURE – WORKSHOP EXPENSE
FOR MAXIMUM COURSE SIZE

A.	Development expense with instructors' preparation costs -	$ 14,958.46
B.	Development expense for the course	$ 10,328.46
C.	Instructor salary for three instructors per course in the Los Angeles area for one-half day	$ 150.00
D.	Instructor salary for three instructors per course outside of the Los Angeles area, for a full day	$ 300.00

The maximum number of students per course is 60.

TABLE XLVII – continued

Number of Courses	Number of Students	COST PER STUDENT* (A+C)/N	(A+D)/N	(B+C)/N	(B+D)/N
1	[illegible]	$251.97	$254.31	$174.64	$177.14
2	120	127.15	129.65	88.71	91.07
3	180	85.60	88.10	59.88	62.38
4	240	64.83	67.33	45.35	48.04
5	300	52.36	54.86	36.93	39.42
6	360	44.05	46.55	31.19	33.69
7	420	38.12	40.62	27.09	29.59
8	480	33.66	36.16	24.01	26.63
9	540	30.20	32.70	21.63	24.13
10	600	27.43	29.93	19.71	22.20

*Office overhead for course not included

TABLE XLVIII

LECTURE – DEMONSTRATION EXPENSE
FOR MINIMUM COURSE SIZE

A.	Development expense with instructor's preparation costs -	$ 14,958.46
B.	Development expense for course	$ 10,328.46
C.	Instructor's salary for one instructor in Los Angeles area for one-half day	$ 50.00
D.	Instructor's salary for one instructor outside of Los Angeles area for one full day	$ 100.00

Minimum number of students per course is 100

TABLE XLVIII – continued

Number of Courses	Number of Students	COST PER STUDENT* (A+C)/N	(A+D)/N	(B+C)/N	(B+D)/N
1	100	$150.08	$150.58	$103.78	$104.28
2	200	75.29	75.79	52.14	52.67
3	300	50.36	50.86	34.93	35.43
4	400	37.90	38.40	26.32	36.82
5	500	30.42	30.92	21.16	21.65
6	600	25.43	25.93	17.71	18.21
7	700	21.87	22.37	15.25	15.76
8	800	19.20	19.70	13.41	13.91
9	900	17.12	17.62	11.98	12.48
10	1000	15.46	15.96	10.83	11.33

*Office overhead for course not included

TABLE XLIX

LECTURE – DEMONSTRATION EXPENSE
FOR MAXIMUM COURSE SIZE

A. Development expense with instructor's preparation costs –	$14,958.46
B. Development expense for course	$10,328.46
C. Instructor's salary for one instructor in Los Angeles area for one-half day	$ 50.00
D. Instructor's salary for one instructor outside of Los Angeles area for one full day	$ 100.00

Maximum number of students per course is 200.

TABLE XLIX – continued

Number of Courses	Number of Students	COST PER STUDENT* (A+C)/N	(A+D)/N	(B+C)/N	(B+D)/N
1	200	$ 75.04	$ 75.29	$ 51.89	$ 53.14
2	400	37.65	37.90	26.67	26.32
3	600	25.18	25.43	17.46	17.71
4	800	18.95	19.20	13.16	13.41
5	1000	15.21	15.46	10.58	10.83
6	1200	12.15	12.97	8.88	9.11
7	1400	10.75	11.84	7.63	7.88
8	1600	9.60	9.85	6.71	6.96
9	1800	8.56	8.81	5.97	6.24
10	2000	7.73	7.98	5.41	5.66

*Office overhead for course not included

CHAPTER XV

SUMMARY AND CONCLUSIONS OF PHASE I, SECTION D

SUMMARY

Statement of the Problem

This study tested the following hypotheses:

1. There are no significant differences in the results of a test of achievement requiring the application of the rules of Spatial Analysis of the Electrocardiogram between two groups of freshman medical students using different modes of instruction: textbook and programmed textbook.

2. There are no significant differences in instructional time to learn the rules of Spatial Analysis of the Electrocardiogram between two groups of freshman medical students using the two modes of instruction: textbook and programmed textbook.

3. There are no significant differences between the means of the predicted gains for the two groups when adjusted for the amount of time spent for learning.

Design of the Study

The subject in this portion D of Phase I of this study were

sixty-eight freshman medical students at the University of Southern California School of Medicine. The experiment took place February 19, 1968.

The subjects were assigned randomly to each of two instructional groups. Two absent subjects and four subjects not following directions were eliminated from the study. The number of subjects was thirty-one for the programmed textbook and thirty-seven for the textbook. The content of instruction was the same for each group. Subjects were pretested, given the instructional treatment, and post-tested. Instructional time was recorded.

The data were collected from the subjects in the form of answers to two tests of plotting mean cardiac vectors in the horizontal and frontal planes from the recordings of the standard 12-lead electrocardiogram and in individual instructional times.

Findings

No significant difference was found in the results of a test of achievement of the application of the rules of Spatial Analysis of the Electrocardiogram among the two groups of freshman subjects using the two modes of instruction. A significant difference was found between means of instructional times for the two modes with the instructional time for the text significantly less than the instructional time for the programmed text. No significant difference was found between the means of predicted gain when the groups were adjusted for the amount of time spent in learning.

CONCLUSIONS

The conclusions were as follows:

1. The authors accepted the hypothesis that there was no significant difference in the results of a test of achievement of the application of the rules of Spatial Analysis of the Electrocardiogram between the two groups of freshman students using the different modes of instruction: a textbook and a programmed textbook.
2. The authors rejected the hypothesis that there was no significant difference between means of instructional time to learn the rules of Spatial Analysis of the Electrocardiogram between the two groups of subjects using the different modes of instruction: a textbook and a programmed textbook.
3. The authors accepted the hypothesis that there was no significant difference between means for predicted gain scores of achievement when the groups were adjusted for the amount of time spent for learning.

CHAPTER XVI

PHASE I – SECTION A, B, C & D

DISCUSSION

The following report which was presented at the Fourth Rochester Conference on Self-Instruction in Medical Education at Rochester, New York on June 26-28, 1968, will serve as the discussion for Phase I, Section A, B, C and D.

EXPERIENCE WITH THREE SUBJECT POPULATIONS WITH COMBINATIONS OF FOUR TEACHING MODES: PROGRAMMED TEXT, TEXTBOOK LECTURE-DEMONSTRATION AND LECTURE-WORKSHOP*

PHIL R. MANNING, M.D.**

STEPHEN ABRAHAMSON, PH.D.***

DONALD A. DENNIS, M.A.****

University of Southern California School of Medicine, Los Angeles

INTRODUCTION

Continuing education for the practicing physician traditionally has emphasized the presentation of facts to groups of passive physicians. Despite considerable lip service to the contrary, those individuals responsible for continuing education usually limit their activities to providing courses designed to promote transfer of information from teacher to student. Little or no effort is made to determine if a physician has the ability or motivation to utilize the information taught. Until very recently little attention has been paid by directors of educational programs for physicians to the relationship of learned facts to

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**Professor of Medicine and Associate Dean, Postgraduate Division.

***Director, Division of Research in Medical Education, and Professor, School of Education.

****Instructional Media Coordinator, Postgraduate Division.

the system of delivery of health care. All four components, i.e. (1) teaching and learning of facts, (2) the ability to utilize facts, (3) the motivation to utilize facts, and (4) the system in which health care will be delivered, are part of the complex problem of continuing education for the practicing physician.

It is clear that as we develop greater ability and understanding in continuing education, already overworked medical school faculties must expand their horizons to include more than the presentation of knowledge. It follows that if faculties are to be asked to do more than they are now asked to do, it will become necessary to develop more effective and efficient means of teaching knowledge. For while knowledge itself gives no assurances that the care of patients will be improved, knowledge is a first step upon which ability and motivation to use knowledge rests. Any improvement of faculty effectiveness and efficiency in the teaching and learning of facts and skills, therefore, will aid in solving more complex problems of continuing education.

We have been interested in studying means by which knowledge can be learned more easily and quickly without increasing the demands on over-extended medical school faculties.

COMPARING FOUR TEACHING METHODS

We previously have reported experience gained in comparing four teaching modes: (1) standard textbook, (2) programmed textbook, (3) lecture-demonstration, and (4) lecture-workshop.[1] One hundred and forty-eight physicians attending a two-day postgraduate course

were divided randomly into four groups. Identical content was presented to each group by a different instructional method. Plotting of mean cardiac vectors in the frontal and horizontal planes from the standard 12-lead electrocardiogram constituted the subject matter. The content material was chosen because the knowledge and skill needed to plot cardiac vectors could be acquired in about three hours and most of the physicians attending knew little or nothing of the method. The physicians in the group were chiefly general practitioners who were attending a two-day postgraduate program which included non-cardiac subjects. Most of them had little interest in and little need for the skill of plotting mean cardiac vectors.

Three faculty members served as teachers of the 148 physicians in the experiment. The same three faculty members prepared the content for each of the teaching modes. The programmed text was written first and there was no question that the textbook and lectures that followed were greatly influenced by the fact that these faculty members had spent approximately 3,000 hours in preparing the program. Identical illustrations and, in most cases, identical phraeseology were used in each of the teaching methods (Figures 1 and 2). The final version of the textbook contained fifty-seven pages of material with many illustrations. A modified branching method with two and three and occasionally four options per teaching frame was utilized for the 149 page programmed text. The physicians randomly assigned to the workshop group had the opportunity of plotting mean cardiac vectors under the supervision of the faculty. In the lecture-demonstration group the student-physicians

merely observed the faculty plotting the vectors. Members of all four groups were given the same 30-item multiple-choice test just prior to and following the teaching presentations. The test required the subjects to plot vectors (Figures 3 and 4).

The results of the pre-and posttests are seen in Table 1. All four groups demonstrated little knowledge on the pre-test and each group scored considerably higher on the posttest. On the basis of the pre-and posttests, it is evident that each of the four instructional modes, (1) the lecture-demonstration, (2) the lecture-workshop, (3) the text-book, and (4) the programmed textbook, provided about the same increase in posttest score over pretest score. Within the limits imposed by the testing instrument the methods were equal to each other in instructing physicians to plot mean cardiac vectors.

The mean time required for learning to take place with each of the four modes is seen in Table 2. The standard textbook and, to a smaller extent, the programmed textbook required less time to produce learning gain than did the lecture-workshop and lecture-demonstration.

DELAYED POSTTESTING

Following our previous report we solicited the original one hundred and forty-eight participating physicians to take a delayed posttest. Of the 148, a total of eight-six returned a delayed posttest by mail. The delayed test was returned to us between three and nine months following the teaching session. The majority of the tests were returned between three and five months. Three reminder letters and additional posttests

were sent to the participants to encourage them to complete the delayed posttest. It will be noted in Table 3 there is no significant difference in the results of the delayed posttest among any of the four teaching methods. While the scores are not as high as they were on the immediate posttest, they are significantly higher than they were on the pretest. It should be recalled that the majority of the physicians who learned this method of plotting vectors had little or no reason to utilize it between the time of the instructional period and the delayed posttest period. Still some retention of the skill of plotting mean cardiac vectors remained.

On comparing the returns of physicians who completed the delayed posttest, it was noted that those who scored in the upper 25% on the immediate posttest were significantly more likely to return a delayed posttest than those who scored in the lower 25% or the immediate posttest (Table 4).

FURTHER EXPERIENCE WITH THE TEACHING METHODS

To amplify our experience we have subsequently carried out two additional testing situations utilizing the same teaching material but with different populations of learners.

The first group of learners consisted of sixty practicing physicians, largely internists, who were interested in electrocardiography and were attending a postgraduate course entirely devoted to electrocardiographic interpretation. The second group of learners consisted of sixty-eight first year medical students who knew little or nothing about electrocardiography.

Internist Group. – With the internist group, comparisons were made among the lecture-demonstration, programmed text and lecture-workshop. The fourth mode was not utilized as the number of physicians participating was not of sufficient size. Again, there was no significant difference in learning gain as measured by the difference between the pretest and the posttest scores among the three teaching methods (Table 5). Each method produced significantly higher scores on the posttest when compared to the pretest. The internist group scored higher than the previous general practitioner group on the pretest, but leveled off with essentially the same posttest score. The lecture-workshop took significantly more time than either the lecture-demonstration or the programmed textbook (Table 6).

Freshman Medical Students. – The programmed textbook and standard textbook were compared on sixty-eight randomly divided first year medical students, most of whom had no experience with plotting of mean cardiac vectors from the standard electrocardiogram. From a possible thirty points, the mean pretest score, for both the programmed text and the textbook was about 2 (Table 7). Following the instruction the posttest score of the programmed text and textbook groups were, respectively, about 28 and 26. The differences in learning gain between methods are again not significant, but each method produced significant learning gain.

The mean instruction time required to complete the programmed text was about eighty-two minutes and for the textbook, sixty-six minutes (Table 8). This is a significant difference.

COST ANALYSIS

In order to further evaluate the various teaching methods, we attempted to estimate the costs that would be required to produce and deliver the four different instructional modes. The cost estimates are tabulated in Tables 9 and 10. It can be seen that if very large numbers of students are to take part in a learning situation the cost of textbooks and programmed textbooks are much less than the in-person presentations. For smaller groups this, of course, is not the case.

DISCUSSION

From the experience with three learning groups it would appear that a programmed textbook and a standard textbook developed from the programmed text achieve essentially equivalent learning gains that a lecture-demonstration and a lecture-workshop do, as measured by comparing pre-and posttest scores. The methods were equally effective on three groups of learners: general practitioners, internists and medical students. All of the groups that underwent the study programs, regardless of their starting point on the pretest, ended up with about the same on the posttest score, i.e. between 22 and 28. It would appear that our testing device put a ceiling on the measurement of achievement. The time necessary for study was somewhat less for the textbook than either the programmed textbook or the presentation methods. When large groups of students are involved it is apparent that the textbook and the programmed textbook are financially more economical than numerous in-person presentations. For smaller groups of learners this is not

the case. In addition to the slight saving in instructional time afforded by the textbook and programmed textbook during the learning session itself, both the textbook and programmed textbook may be utilized at a time and place most convenient to the learner. Time traveling to and from conventional medical meetings might more profitably be spent in home study as far as the learning of facts are concerned.

It is difficult to draw exact and complete inferences concerning the relative value of standard textbook learning and programmed textbook learning. Care was taken to be certain that the same illustrations and the same phraseology were used in both methods. However, it must be emphasized that the authors spent a great period of time in organizing the programmed text prior to the writing of the textbook itself. This organization had profound effects on the outcome of the textbook itself. Basically the textbook was developed from the programmed text. The preparation of the lectures and workshops was also greatly influenced by the previous programming experience.

CONCLUSIONS

A standard textbook and a programmed textbook designed to teach the plotting of mean cardiac vectors from the standard electrocardiogram provided similar learning gain as determined by pre-and posttesting as did a lecture and lecture-demonstration on the same materials given by the same instructors. Because the authors spent much time in defining objectives in preparing the programmed textbook prior to the preparation of the textbook and lectures, these latter

methods were undoubtedly greatly influenced.

The time required for study of the textbook was somewhat less than that required for the programmed text and the presentation methods. The great advantage of the textbook and the programmed textbook is that a physician may study them at a time and place most convenient to him without the investment of travel time to and from an in-person teaching presentation. When larger numbers of learners are involved the per-student cost of a textbook and programmed textbook is significantly less than multiple in-person presentations.

TABLE 1

PRETEST AND IMMEDIATE POSTTEST SCORES

GENERAL PRACTITIONER GROUP

Teaching Modes	No. of Partici-pants	Pretest Mean Score	SD	Posttest Mean Score	SD
Programmed text	37	6.1	7.4	22.0	8.5
Lecture-workshop	40	3.4	6.9	22.4	7.3
Textbook	35	9.0	8.0	24.4	7.1
Lecture-demonstration	36	7.2	9.0	22.4	8.2
All groups	148	6.3	8.0	22.8	7.8

TABLE 2

INSTRUCTIONAL TIME FOR THE FOUR TEACHING MODES

GENERAL PRACTITIONER GROUP

Teaching Mode	No. of Participants	Mean Time (Minutes)	SD
Programmed text	22	72.8	16.2
Lecture-workshop	47	80.0	0.0
Textbook	26	48.9	20.2
Lecture-demonstration	36	90.0	0.0

TABLE 3

DELAYED POSTTEST SCORES

GENERAL PRACTITIONER GROUP

Teaching Modes	No. of Partici-pants re-turning Delayed Posttest	Pretest Mean Score for Delayed Posttest Participants	SD	Delayed Posttest Mean Score	SD
Programmed text	22	5.9	5.9	15.[illegible]	11.4
Lecture-workshop	21	5.1	8.7	13.9	12.4
Textbook	22	9.9	8.9	15.6	11.0
Lecture-demonstration	21	8.3	9.6	16.3	12.1
All groups	86	7.3	8.7	15.2	11.5

TABLE 4

RELATIONSHIP BETWEEN POSITION ON POSTTEST
AND RETURN OF DELAYED POSTTEST

GENERAL PRACTITIONERS

		DELAYED POSTTEST	
		Returned	Not Returned
POSTTEST	Upper Quartile	28	9
	Lower Quartile	13	24

Significant difference beyond .005

TABLE 5

RESULTS OF PRE-AND POSTTESTS

INTERNIST GROUP

Teaching Mode	No. of Participants	Pretest Mean Score	SD	Posttest Mean Score	SD
Lecture-demonstration	18	17.3	9.6	25.4	3.8
Programmed text	22	18.4	9.5	26.1	5.1
Lecture-workshop	20	12.6	9.5	23.5	6.6

TABLE 6

INSTRUCTION TIME FOR THE THREE TEACHING MODES

INTERNIST GROUP

Teaching Mode	No. of Participants	Mean Time (Minutes)	SD
Lecture-demonstration	18	72.0	0.0
Programmed text	22	77.7	24.9
Lecture-workshop	20	117.0	0.0

TABLE 7

RESULTS OF PRE-AND POSTTESTS

FRESHMAN MEDICAL STUDENTS

Teaching Mode	No of Partici-pants	Pretest Mean Score	SD	Posttest Mean Score	SD
Programmed text	31	1.9	4.0	27.6	4.1
Textbook	37	2.1	4.4	26.3	4.2

TABLE 8

INSTRUCTION TIME FOR BOTH MODES

FRESHMAN MEDICAL STUDENTS

Teaching Mode	No. of Participants	Mean Time (Minutes)	SD
Programmed text	31	81.7	15.2
Textbook	37	66.1	18.0

TABLE 9

COST ANALYSIS - TEXTS*

	No. of Texts	Textbook Cost per Student	Programmed Text Cost per Student
Printing	300	$ 53.82	$ 55.54
	500	32.50	35.36
	1,000	16.58	18.17
	2,500	6.57	7.61
	5,000	3.73	4.24
	10,000	2.13	2.51
	20,000	1.28	1.60

*Includes preparation and printing costs with minimal fees to authors.

TABLE 10

COST ANALYSIS

GROUP PRESENTATION

Basic Expenses		
Photography	$	136.00
Art Work		275.00
Overhead Mailing and printing (10,000 brochures)		600.00
	$	1,011.00

	Lecture-workshop (60 students)	Lecture-demonstration (100 students)
Basic Expenses	$ 1,011.00	$ 1,011.00
Instructors	225.00	75.00
	$ 1,236.00	$ 1,086.00
Cost per student	$ 20.60	$ 10.86

REFERENCE

1. Manning, Phil R., Stephen Abrahamson, and Donald A. Dennis. "Comparison of Four Teaching Techniques: Programmed Text, Textbook, Lecture-Demonstration and Lecture-Workshop," J. of Med. Ed., 43:356-59, March, 1968.

PHASE II

WILSON'S DISEASE

CHAPTER XVII

PHASE II

SUBJECTS, TECHNIQUES, AND PROCEDURES

SUBJECTS

The subjects for Phase II of this study were drawn from participants in the following courses: "Intensive Review of Internal Medicine," September 18-29, 1967; "Bedside Clinic and Set-Clinic in Internal Medicine," September 21 to December 14, 1967; and "Ward Walks in Rare Diseases," April 4 to June 13, 1967.

DESIGN OF THE STUDY

Phase II was designed to gather data on the effects of different modes of instruction on physician achievement. It was hypothesized there are no significant differences among groups of physicians in the results of a test of knowledge requiring the application of the information taught by one of the following modes of instruction: (1) lecture with slides, (2) set-clinic with slides, (3) lecture with film of the patient and slides, and (4) bedside teaching with slides.

Statistical Techniques

Measurement of achievement. – As stated in the general research design, the subjects could not be assigned to instructional modes

at will. Therefore, intact groups participating in the postgraduate courses were used. The statistic chosen was the analysis of covariance to test the significance of differences between the final experimantal data- the posttest - by taking into account and adjusting for initial differences between the groups on the pretest. The analysis of covariance statistically matched the subjects for the researchers.

Experimental Variables

Those subjects participating in the course, "Intensive Review of Internal Medicine," were randomly assigned, by use of a table of random numbers, to each of three groups. Each group was randomly assigned to one of the following instructional modes: (1) lecture with slides, (2) lecture with a movie of a patient and slides, and (3) set-clinic using the patient who was filmed and slides.

Internists participating in the "Bedside Clinic and Set-Clinic in Internal Medicine" course were randomly assigned to two groups to be taught at the bedside using the patient who was filmed and the slides. Internists participating in the "Ward Walks in Rare Diseases" were randomly assigned to two groups to be taught at the bedside with the patient who was filmed and the same slides. All participants in the bedside teaching modes were combined into one group for statistical analysis.

Instructional Treatment. – All groups were taught by the same instructor, Telfer B. Reynolds, M.D., Professor of Medicine at the University of Southern California. One patient was used as the basis

for the instruction in the four modes.[1]

Lecture. – The subjects heard a lecture on Wilson's Disease supplemented by 3-1/4"x4" colored pathological slides.

Set-clinic. – Those subjects in the set-clinic were in an auditorium setting where the patient was exhibited in the front of the room, examined by the instructor and interested participants, findings were presented by the instructor and the case history was presented, supplemented with 3-1/4x 4" colored pathological slides.

Lecture with film. – Those subjects in the lecture with film were in an auditorium setting. The lecture was supplemented by a film of the patient presented in the set-clinic and the 3-1/4"x4" colored pathological slides.

Bedside teaching. – Those subjects taught at the bedside saw the same patient presented in the set-clinic as was filmed for the film mode. The patient was presented in the teaching room of the Los Angeles County - USC Medical Center. The patient was examined by the subjects, findings were presented, and the case history was presented by the instructor supplemented with 3-1/4"x4" colored pathological slides.

PROCEDURES

Preparation of Instructional Materials

Telfer B. Reynolds, M.D. developed the course content from

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[1] Appendix P

the case history of a patient exhibiting Wilson's Disease. Four patients were considered in the initial portion of the development of the material. These patients were filmed for the study. Dr. Reynolds selected the patient using the following criteria: The ability of the patient to withstand repeated examinations, the cooperation and availability of patient over an extended period of time, the number of signs exhibited, and the likelihood of stable clinical manifestations.

The patient-film was photographed and edited by the senior research assistant in cooperation with Dr. Reynolds.

Preparation of the Test

The test was developed by Telfer B. Reynolds, M.D. with assistance on test format and the wording of individual items by the researchers. The same test was used for the pre-and posttest.[2]

Preparation of the Tests

Each subject was given a four digit identificatio number. The first digit signified the treatment group. The last thre gits signified the numerical position of the subject's name on the or inal registration list used for the randomization of the subjects to he instructional treatments.

Pretest

"Intensive Review of Internal Medicine. – The pretest was given the morning of the day before the experimental treatment. On September 25, 1967, the day of the pretest, the subjects were asked to register. At this time, a card with their identification number was given

[2] Appendix Q

each participant. They were instructed to use this card later in the day when they would be required to use the identification number.

At the designated time, thepretests were passed out by the secretaries. The subjects were instructed to write their identification number in the appropriate places. They were then told to begin and would be given one-half hour to complete the test.

After the tests were collected, the subjects were advised that during "Photos and Discussion of Disease - Some Common, Some Rare," from 8:00 a.m. to 12:15 p.m. of the next morning, they were to be divided according to their identification number into three groups. Those with identification numbers beginning with "1" were to go to Room 1436. Those with identification numbers beginning with a "2" were to go to the main auditorium. Those with identification numbers beginning with a "3" were to go to Room 1645. The subjects were told they would be given the same content with the instructors rotating among the groups. They were asked to please report to the correct room.

"Bedside Clinic and Set-Clinic in Internal Medicine."– The pretest was given to the internists participating in this course on December 7, 1967 at 7:30 in the evening. The internists and the other participants had been given an identification number. The same list was used to randomly assign the internists to two groups, A and B. The other subjects were contained in Groups C-F; Group A contained twelve subjects; Group B contained 12 subjects.

As the participants of the course arrived on the evening of

December 7 they were given the examination at a registration table, and were told to go inside the lecture hall, Room 1645 to take the test. One-half hour was allotted to complete the examination.

"Ward Walks in Rare Diseases." – The internists participating in this course were assigned an identification number according to the registration list. They were randomly assigned to two groups. The identification number contained the letter A or B and a three digit identification number which was the subject position on the registration list.

The pretest was given April 4, 1968 at 7:30 p.m. which was the beginning hour for the course. One-half hour was allowed for the examination. The pretests with the identification number were passed out at the registration desk. The subjects were told to take the examination and to return it when they were finished.

Instructional Treatments

Intensive Review, Group 1. – The participants assigned to Group 1 were given a lecture based upon a case history of Wilson's Disease and were shown 3-1/4"x4" colored pathological slides. Immediately at the close of the question period the posttest was given. The subjects were requested to write their identification number in the appropriate places and were allowed thirty minutes to complete the examination.

Intensive Review, Group 2. – The participants assigned to Group 2 were given a lecture based upon a case history of Wilson's Disease and were shown 3-1/4"x 4" colored pathological slides, and

a 16 mm. color silent film of the patient which was also presented to Group 3 in the Set-clinic. Immediately at the close of the question period, the posttest was given. The subjects were requested to write their identification number in the appropriate places and were allowed thirty minutes to complete the examination.

Intensive Review, Group 3. – The participants assigned to Group 3 were given the same information in a set-clinic teaching session. The patient was brought into the front of Room 1645, a theatre-style lecture-hall with graduated levels of seat rows. Questions were asked of the patient and instructor and the instructor examined the patient and related his finding. Interested physicians came forward to collaborate the instructor's findings. The 3-1/4" x 4" colored pathological slides were shown.

Immediately at the close of the question period, the posttest was given. The subjects were requested to write their identification number in the appropriate places and were allowed thirty minutes to complete the examination.

Bedside Clinic and Set-Clinic in Internal Medicine. – The internists participating in this course were randomly assigned to two groups, A and B. All of the groups, A-F, in this course reported to one room to obtain the number of the room to which they were to report. The evening of December 14, 1967 Group A was taught the information at the bedside the first half of the course; Group B was taught the second half of the course. The bedside patient was the same as was used in the set-clinic. Immediately at the end of the instructional session, the subjects were posttested. They were given thirty minutes to complete the test.

Wardwalks in Rare Diseases. - The internists participating in this course were randomly assigned to Groups A and B. Group A was to be taught the information in bedside teaching for this study while Group B was to receive other material relevant to the course in another room. Upon completion by Group A of the posttest, the groups were to exchange rooms and the same procedures followed as planned for the bedside teaching. The instructor for the other group had a serious emergency illness in his immediate family, therefore, the two groups were combined. The combined group was treated the same as the previous bedside teaching session. Subjects examined the patient, the patient was exhibited for other visible signs, and the case history was developed as in the other sessions supplemented by 3-1/4" x 4" colored pathological slides.

Immediately after the teaching session, the subjects were asked to take the posttest.

Scoring

The pretests and posttests were placed in the numerical order each subject verified for a pre-and posttest. Those subjects who were absent either of the examination times were elimiated from data evaluation. Data cards, 100% verified, were punched with the subjects identification number and individual item responses in appropriate feilds.

A key data card was used to score the data cards by hand. This was done twice with a week between scorings as a reliability check. The scores were transferred to a master sheet where the subjects were listed by name and identification number.

For each subject, his identification number, pretest score, and posttest score were punched in data cards.[3] The appropriate statistical technique was used to analyze the data.

SUMMARY

The subjects for Phase II of this study were from three post-graduate courses: (1) "Intensive Review of Internal Medicine," (2) Bed-side Clinic and Set-Clinic in Internal Medicine," and (3)"Ward Walks in Rare Diseases." The instructional modes and the test were developed. Those subjects in course 1 listed above were randomly assigned to one of three modes of instruction (a) lecture with slides, (b) lecture with patient movie and slides, and (c) set-clinic. Those subjects in course 2 and 3 were randomly assigned to small groups for bedside teaching. These small groups were combined for statistical analysis for comparing the four instructional modes.

The data were collected and treated statistically with analysis of covariance and analysis of variance using computer programs.

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[3] Appendix R

CHAPTER XVIII

PHASE II

PRESENTATION OF THE DATA, FINDINGS AND INTERPRETATIONS

PRESENTATION OF THE DATA

Phase II of this study was to investigate the hypothesis that there are no significant differences among the groups of physicians in the results of a test of knowledge requiring the application of the information taught by the following modes of instruction: (1) lecture with slides, (2) set-clinic with slides, (3) lecture with slides and a film of the patient, and (4) bedside teaching with the same patient as filmed and with slides.

Table L presents the results of the pre-and posttest for the four groups.

TABLE L

Method	Pretest $\bar{X}$	Pretest S. D.	Posttest $\bar{Y}$	Posttest S. D.	N
Lecture	33.37	4.67	45.80	4.48	40
Lecture-movie	32.58	4.72	45.85	2.65	48
Set-clinic	32.04	6.23	46.33	4.90	45
Bedside	31.48	4.28	43.83	3.05	23

Table LI presents the results of the analysis of variance on the pretest data.

TABLE LI

RESULTS OF ANALYSIS OF VARIANCE ON THE PRETEST

Source	S.S.	d.f.	M.S.	F
Between groups	64.1	3	21.38	.81 N.S.
Within groups	4006.7	152	26.36	
Total	4070.8	155		

As seen, the F ratio for the pretest was not significant.

Table LII presents the results of the analysis of variance on the posttest data.

TABLE LII

RESULTS OF ANALYSIS OF VARIANCE ON THE POSTTEST

Source	S.S.	d.f.	M.S.	F
Between groups	[illegible]	3	33.43	2.14 N.S.
Within groups	2375.7	152	15.63	
Total	2476.0	155		

As seen, the F ratio for the posttest was not significant.

Table LIII presents the results of the analysis of covariance on pretest and posttest data.

TABLE LIII

RESULTS OF ANALYSIS OF COVARIANCE ON PRETEST AND POSTTEST

Source	S.S.	d.f.	M.S.	F
Adjusted means	83.0	3	27.67	2.3 N.S.
Within groups	1815.4	151	12.02	
Total	1898.4	154		

As seen, the results of the analysis of covariance on the pretest and posttest was not significant. The correlation coefficient within groups was .49. The correlation coefficient between means was .44, and the correlation coefficient total Y on X was .48.

FINDINGS

From Table LIII it may be seen that the F ratio for modes was not significant for achievement.

INTERPRETATION OF THE DATA

Since the F ratio for the instructional modes was not significant and the slopes of the four regression lines were about the same as indicated by the correlation coefficient within groups and the correlation coefficient total Y on X.

It was concluded there was no significant difference in the results of a test of knowledge among the groups of physicians requiring the application of information taught by the modes of instruction: (1) lecture with slides, (2) set-clinic with slides, (3) lecture with slides and a film of the patient, and (4) bedside teaching using the patient and slides.

CHAPTER XIX

COST ANALYSIS – PHASE II

FOR DEVELOPMENT OF THE INSTRUCTIONAL MODES

Table LIV presents the mailing overhead costs for the course as the general expense total and the instructors development cost included in the last total.

TABLE LIV

Mailing Costs	$ 284.75
Overhead	631.75
Total - General Expenses	$ 916.50
Development Expense for Telfer B. Reynolds, M.D. - Instructor	$ 2,200.00
Total Expense	$ 3,116.50

Table LV presents the expense for each mode: lecture, lecture with fil. ı, set-clinic and bedside. Total A is the cost within the instruction development. Total B is the cost with the instructor's development cost included.

TABLE LV

ACTUAL COST PER MODE FOR PHASE II

	Lecture	Lecture with film	Set clinic	Bedside	Lecture with film*
	N=40	N=48	N=45	N=23	N=48
General expenses	$229.13	$ 229.13	$229.13	$229.13	$229.13
Instructor-$20.00 per hour	20.00	20.00	20.00	60.00	20.00
Slides	4.25	4.25	4.25	4.25	4.25
Film	______	364.00	______	______	42.00
Cost without development expenses (A)	253.38	617.38	253.38	293.38	295.38
Development expense (B)	550.00	550.00	550.00	550.00	550.00
Cost with course development expenses (A & B)	$803.38	$ 1167.38	$803.38	$843.38	$845.38

*Cost of actual film footage used in teaching course.

Table LVI presents the cost per student for each mode. Two sets of figures are presented, one usint Total A and the other using Total B. The differences in the totals are evident.

TABLE LVI

ACTUAL COST PER STUDENT PER MODE

	Lecture	Lecture with film	Set clinic	Bedside	Lecture with film*
	N=40	N=48	N=45	N=23	N=48
Total A, Table LV	$ 6.33	$12.86	$ 5.63	$12.76	$ 6.15
Total A&B, Table LV	$20.08	$24.32	$17.85	$36.67	$17.61

*Cost of actual film footage used for course.

Table LVII presents a projection of the cost over larger populations using only the general expenses, slides, film and instructor time cost as shown in Table LVII.

TABLE LVII

COURSE COST AND COST PER STUDENT FOR LARGER POPULATIONS WITHOUT COURSE DEVELOPMENT COST

	N	Lecture	Lecture with film	Set clinic	Bedside	Lecture with film**
Course Cost	64	$253.38	$617.38	$253.38	$393.38*	$295.38
Cost per Student		3.96	9.65	3.96	6.15	4.62
				*8 sessions of 8 students		
Course Cost	128	$253.38	$617.38	$253.38	$553.38*	$295.38
Cost per Student		1.98	4.82	1.98	4.32	2.31
				*16 sessions of 8 students		
Course Cost	160	$253.38	$617.38	$253.38	$633.38*	$295.38
Cost per Student		1.58	3.86	1.58	3.96	1.85
				*20 sessions of 8 students		

** Cost of actual film footage used for course

Table LVIII presents a projection, the cost over larger population using all expenses.

TABLE LVIII

COURSE COST AND COST PER STUDENT
FOR LARGER POPULATIONS
WITH COURSE DEVELOPMENT COST

	N	Lecture	Lecture with film	Set clinic	Bedside	Lecture with film**
Course cost	64	$803.38	$1167.38	$803.38	$ 943.38*	$845.38
Cost per Student		12.55	18.24	12.55	14.74	13.21
				*8 sessions of 8 students		
Course cost	128	$803.38	$1167.38	$803.38	$1103.38*	$845.38
Cost per Student		6.28	9.12	6.28	8.62	6.60
				*16 sessions of 8 students		
Course cost	160	$803.38	$1167.38	$803.38	$1183.38*	$845.38
Cost per Student		5.02	7.30	5.02	7.40	5.28
				*20 sessions of 8 students		

** Cost of actual film footage used for course.

DISCUSSION

The cost analysis can be approached from Table LV using general course expense (A), the total course expense (A+B), or for the film portion, using only the actual footage cost of the film as shown to the far right of Table LV.

The data in Table LVI using total A indicates a dichotomy of lecture and set-clinic as the less expensive courses versus lecture with film and bedside as the more expensive courses. When using the

data of A+B from Table LVI, we find the beside becomes increasingly more expensive than the other three modes. It should be noted that four patients were filmed and the criteria described in the procedures for Phase II determined which patient and film was used.

As seen in Tables LV and LVI, when only the film used in the course was considered, the lecture with film course cost per student decreases markedly. It is important that all costs be considered in this analysis. The point is, however, were this film available before the course was created, the cost would be quite different than shown in the other totals and the cost analysis unintentionally biased toward one or more modes of instruction; thus this film course cost was shown for comparison with the other course costs.

The examination in Phase II generally tested for verbal information. The four instructional modes showed no differences in achievement. The visual information given by the patient in the set-clinic, the bedside teaching, and the film was [illegible] ed. Data about the application of knowledge to patient care were gathered in Phase III. Were cost and verbal information the sole criteria for the development of the course, the set-clinic was the more economical since this course accommodated a large number of subjects and was the least expensive when compared with the other three modes on cost per subject. If the film cost for only the patient used in the course is considered, then the lecture, the lecture with film and the set-clinic are all three economical, determined by the cost per pupil as seen in Table LVI.

The projected costs over larger population may provide a better

basis for comparison. As shown in Table LVII, for sixty-four subjects, the costs of the lecture and set-clinic would be \$3.95; the bedside teaching \$6.15; the lecture with all the film costs would be \$9.65; the lecture with only the film of the one patient would be \$4.62. The comparison for 128 and 160 subjects is also shown.

The cost differential is not the only critical factor in determining the more economical course. Time and patient availability are also key factors. The bedside teaching sessions must be repeated eight times for sixty-four subjects. This is approximately eight hours of instruction compared with approximately one hour of instruction for each of the other three modes. The instructor must be prepared to repeat the same information and go through the same procedures eight times with the patient. This might prove to be quite difficult. The teaching may not be consistent in information and patient presentation over the eight sessions.

The patient must be made available. In-patients may not be available and out-patients must be utilized. As stated in the criteria for the choice of the patient, were the clinical signs constant for the period of time that the patient was used? Was the patient able to be transported to the classroom and was the patient well enough to undergo repeated exposure in the course settings?

The above problems with the beside teaching are magnified as the number of sessions are increased. Thus, from cost per student, patient availability, instructor time, and teaching consistency, it is felt that the bedside teaching session was not efficient when the teaching is to increase the level of the physicians' information and factual

material. A very sophisticated procedure of pre-and post observation of clinical behavior is needed to evaluate behavioral changes in patient care as a result of the instruction and to investigate the impact of both the verbal and visual stimuli presented.

The lecture and the set-clinic were the more economical of the four modes when projected to larger populations as seen in Tables LVII and LVIII. The same problems concerning the patient may arise for the set-clinic as indicated above in the discussion concerning the bed-side teaching.

The measurement of the information learned was primarily verbal in nature and the contribution of the visual stimuli in the set-clinic, the film, and the bedside teaching was not measured. Therefore, the cost analysis in terms of cost versus teaching effectiveness cannot be evaluated on the visual elements in the instructional settings.

Since there were no significant differences among the four modes for learning, the lecture without the complications of the patient was found to be the most efficient mode as shown by cost, ease or preparation, and test data. Again, it must be emphasized that the effect of the visual stimuli was not evaluated, leaving unanswered the change in the information level of the participating physician and the carry over to patient care as a result of visual stimuli.

CHAPTER XX

PHASE II

SUMMARY AND CONCLUSION

SUMMARY

Statement of the Problem

This phase of the study was to test the hypothesis that among the groups of physicians there are no significant differences in the results of a test of knowledge requiring the application of the information taught by the following modes of instructions: (1) lecture with slides, (2) set-clinic with slides, (3) lecture with slides and a film of the patient, and (4) bedside teaching with the patient that was filmed and the slides.

Design of the Study

The subjects, for Phase II of this study, were drawn from participants in the following courses: "Intensive Review of Internal Medicine," September 18 to 29, 1967; "Bedside Clinics and Set Clinics in Internal Medicine," September 21 to December 14, 1967; and "Ward Walks in Rare Diseases," April 4 to June 13, 1967.

The subjects from the "Intensive Review of Internal Medicine" were assigned randomly to the first three instructional groups stated in the above hypothesis. Participants in the "Bedside Clinics and Set Clinics in Internal Medicine" and "Ward Walks in Rare Diseases"

were assigned randomly to small teaching groups for the bedside teaching mode.

The data were collected from the subjects in the form of answers to a pretest and posttest of knowledge of Wilson's Disease.

Findings

No significant difference was found in the results of a test of achievement among the groups of physicians using the four modes of instruction.

CONCLUSION

The researchers accepted the hypothesis that there are no significant differences in the results of a test of knowledge among the groups of physicians requiring the application of information taught by the four modes of instruction: (1) lecture with slides, (2) set-clinic with slides, (3) lecture with slides and a film of the patient, and (4) bedside teaching using the patient who was filmed and the slides.

CHAPTER XXI

PHASE III

INTERVIEWS

Phase III of this contract was to "develop a methodology by which interviewing techniques may be utilized to obtain precise data from a sample of the physicians participating in the seven programs in Phases I and II."

Research Design

A random sample of the physicians participating in the Electrocardiogram Course at the California Medical Association Conference, March 2 and 3, 1967, was selected. Ten physicians from each of the four instructional modes were selected for interviewing. From those participants in the Intensive Review of Internal Medicine, a random sample was chosen of ten physicians from each of the three instructional modes for the Wilson's Disease Course, a portion of the rare disease section of the Intensive Review Course.

The Instrument

It was not the intent of the investigators to develop an interview instrument to examine orally the retention of information. The purpose was to obtain data on how the information learned was being used in the medical practice of the physician. The data, by necessity, were attitudinal since the interview method obtains this type of data.

Questions were developed which attempted to obtain data which would show perceived changes in behavior.

The interviewers' instrument was evolved by the investigators during the summer of 1967. Tentative questions for the instrument were developed both as open and closed questions. As stated by Oppenheim, a subject is stimulated upon answering a question to respond using attitudinal data which may be clear and well organized or quite diffuse and vague.[1] The investigators attempted to write questions which would provide useful data, and not data obtained through: (1) a respondent's wishful thinking, (2) a desire on the respondent's part to give an acceptable answer, (3) a desire to give an answer which the respondent felt would please the researchers, or (4) an answer given to please the interviewer.

The questions were kept as short as possible. The general pattern was from general questions to specific probing questions which were open-ended. The wording of the questions was such as to eliminate, as much as possible, leading questions or loaded questions. Leading questions were defined as questions so worded that they were not neutral. A loaded word was defined as a word or phrase which might stimulate an emotional response rather than a cognitive response on the part of the interviewee. Questions were worded so as to eliminate as much as possible the leading bias in the formulation of

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[1]Oppenheim, A. N. <u>Questionnaire Design and Attitude Measurement</u>, p. 50. Basic Books, Inc., New York, 1966.

the probes, and the probes were left open-ended in most cases and as neutral as possible.

Repeated revisions resulted in a trial questionnaire. This format was field tested with physicians who had participated in the course and with the instructors of the courses. The final form of both interview instruments contained closed and open-ended questions. The Electrocardiogram Interview instrument is in Appendix U; the Wilson's Disease Interview instrument is in Appendix V.

The attitudinal data obtained were: (1) In what areas did the participant feel the course had contributed to a gain in understanding, (2) In what areas did they feel they had received information that was of immediate practical value, (3) Had there been a change in interest in the subject matter as a result of the learning experience, and (4) Had he perceived in himself a change in his behavior in the practice of medicine as a result of the learning experience.

Procedures

The physicians were contacted by telephone by the research assistant and appointments were arranged for the interviews. From applications submitted by interested Junior and Senior medical students interviewers were chosen. The interview form was discussed with each of the interviewers and each interviewer tried both forms and procedures for interviewing. Any questions which arose concerning the use of the form were then explained.

Each interviewer was given a schedule of the physicians to be interviewed. This schedule contained for each subject the following

data: Name, address, telephone number, identification number, date, time and place of the interview. Each interview form was pre-numbered and a card containing the above data was stapled to it. Data were collected during the Christmas recess.

PRESENTATION OF THE DATA

Wilson's Disease Interview

Group A received the lecture with slides treatment, Group B received the lecture with movie and slides treatment, and Group C received the set-clinic treatment.

The Question No. 1 - "What did you think of the Wilson's Disease portion of the Intensive Review of Internal Medicine Course?" was used as an entry question and will not be considered as a portion of the analysis of the data.

When answering Question No. 2 - "Do you feel you have a better understanding of Wilson's Disease now than before taking the Course?" all ten subjects interviewed for each of the three groups indicated that they felt they had a better understanding. In response to question 2-A "In what areas do you feel there has been a gain in understanding?" two subjects in group A and one subject in group B responded only to a - "A greater understanding of the etiology of Wilson's Disease." In group A one subject responded only to b - "A greater understanding of the pathology of Wilson's Disease." In group A two subjects and in group C one subject responded only to part c - "A greater understanding of the pathogenesis of Wilson's Disease." The category d labeled Other was reassigned the label "General awareness of Wilson's Disease" as part of the analysis of the data. One subject in group B responded to d as having a general greater awareness of Wilson's Disease. Two subjects in group A, four subjects in group B and five subjects in group C responded to a - "A greater understanding of the etiology of Wilson's Disease."; b - "A greater understanding of the pathology of Wilson's Disease."; c - "A greater understanding of the pathogenesis of Wilson's Disease."

One subject in group A and two subjects in group B responded to b - "A greater understanding of the pathology of Wilson's Disease," and c - "A greater understanding of the pathogenesis of Wilson's Disease." One subject in group A, one subject in group B and one subject in group C responded to Other in such a manner that the response was labeled under Question No. 5. One respondent in group B gave no reason for responding to Other.

In answering Question No. 3 - "Has there been a change in your interest in Wilson's Disease since taking the course?" three in group A indicated "Yes", seven indicated "No"; three in group B indicated "Yes", seven indicated "No"; eight in group C indicated "Yes", two indicated "No."

For those indicating "Yes" in answer to the question "Which way is the change in interest?" three each in group A and group B indicated positively and eight in group C indicated positively, which was the same number as those just indicating "Yes."

Responses to the open-ended Question No. 3 - A "How did the course accomplish this?" were given the following catagories for coding purposes:

a. The course stimulated interest by encountering information to increase an awareness of Wilson's Disease.

b. The course gave a concise summarization of data.

c. The pretest demonstrated a lack of knowledge of Wilson's Disease.

d. This was accomplished by the use of the visual media in teaching.

e. This was accomplished by the instructor's personality.

In group A two subjects - in group B two subjects and in group C four subjects responded in a manner to be catagorized under a - "The course stimulated interest by encountering information to increase awareness of Wilson's Disease." One in group A responded to b - "The course gave a concise summarization of data." One in group B and one in group C responded that the pretest demonstrated a lack of knowledge of Wilson's Disease. One in group C responded to e - "The instructor's personality." One in group B responded to both a - "The course stimulated interest by encountering information to increase the awareness of Wilson's Disease," and c - "The pretest demonstrated a lack of knowledge of Wilson's Disease." One person in group C responded to a - "The course stimulated interest by encountering information to increase awareness of Wilson's Disease," to part c - "The pretest demonstrated a lack of knowledge, and to part d - "This was accomplished by the use of the visual media in teaching." One subject in group C responded to a - "The course stimulated interest by encountering information to increase awareness of Wilson's Disease," and to e - "This was accomplished by the instructor's personality."

Those subjects answering "No" to Question No. 3 - "Has there been a change in your interest in Wilson's Disease since taking the Course?" were asked the open-ended Question No. 3 - B "If no: Have

you any reasons for this?" The following catagories were used for coding the responses.

a. none

b. not interested

c. not encountered

d. a rare disease

e. previously aware and interested already before the course, with the course just increasing in perception.

f. Can't get lab tests at the hospital.

One of group A and one of group B indicated "None". One of group B indicated the disease had not been encountered. Five of group A and one of group B indicated the reason for the lack of changed interest was because of the infrequency of this as a rare disease. One of group A, three of group B and one of group C did not have a change of interest since they were previously aware and interested in the disease before taking the course and the course only increased their perception. One of group C, who answered "No" to the change in interest in Wilson's Disease indicated this was because he could not get the necessary laboratory tests at the hospital where he practiced.

In answer to Question No. 4 - "Have you sought further information about Wilson's Disease since taking the course?" one in group A indicated "Yes", one in group B indicated "Yes" and five in group C indicated "Yes". Nine in group A indicated "No", nine in group B indicated "No", and five in group C indicated "No". For those answering "Yes" and responding to the question "From what

source have you sought this information?" a. - Book, b. - Journal, c. - Conference, d. - Course, e. - Colleagues, f. - Other, one individual in group A responded by answering a. - Book, b. - Journal, c. - Conference, e. - Colleagues. One subject in group D checked b. - Journal. In group C two subjects checked both a. - Book and b. - Journal and three subjects checked a. - Book.

In response to Question No. 5 "What type of useful information do you feel you obtained as a result of taking Wilson's Disease?" The following categories were given: a. Signs, b. Symptoms, c. Tests, d. Theory, e. Diagnosis and f. Other. For coding purposes 'f', was reassigned the word Therapy.

One subject in group B and one subject in group C responded only to a. Signs. One subject in group A, three subjects in group B responded to a. Signs and b. Symptoms. One person in group C responded to a. Signs, b. Symptoms and c. Tests. One individual in group A and one individual in group B and one individual in group C responded to a. Signs, b. Symptoms, c. Tests, d. Theory and e. Diagnosis. Three subjects in group A and one subject in group C responded to a. Signs, b. Symptoms, c. Tests, and e. Diagnosis. One individual in group A and two subjects in group C responded to a. Signs, b. Symptoms, and e. Diagnosis. One individual in A responded to a. Signs, b. Symptoms, c. Tests, d. Theory and f. classified as Therapy. One individual in group C checked a. Signs, b. Symptoms, c. Tests, e. Diagnosis, d. Therapy. One individual in group C checked a. Signs, b. Symptoms, e. Diagnosis, and

f. Theory. One in group C checked a. Signs, e. Diagnosis, and f. Theory. One in group A responded to a. Signs and e. Therapy. One in group A and one in group B responded to c. Tests, and e. Diagnosis. One in group B responded only to c. Tests. Two in group B responded only to d. Theory. One in group A and one in group C responded only to e. Therapy.

In answer to the Question No. 6 "Are you doing anything different in your work?" three of group A indicated "Yes", seven indicated "No", one of group B indicated "Yes" and nine indicated "No", four of group C indicated "Yes", six indicated "No".

The responses for 6-A "If yes: What are you doing different?" were coded as:

a. I am more aware of signs and symptoms

b. I search for the disease in the patient

c. I am ordering more lab tests on suspected patients.

One in group A and one in group C responded to a. - "They are more aware of the signs and symptoms." One in group A, one in group B and one in group C responded to b. - "I search for the disease in the patients." One in group A responded to a. - "I am more aware of signs and symptoms," and b. - "I search for the disease in the patients." One in group C responded to b. - "I search for the disease in the patient" and c. - "I am ordering lab tests on suspected patients." One in group C responded to c. - "I am ordering more lab tests on suspect patients."

In answer to the Question No. 7 "Have you come across

Wilson's Disease since taking the course?" all three groups of ten were unanimous in saying "No", although one indicated that the information helped to disprove a suspect Wilson's Disease case.

Electrocardiology Interview

Group I received the programmed text treatment; Group II the lecture-workshop; Group III received the textbook treatment, and Group IV the lecture-dmonstration.

Question No. 1. - "What did you think of the ECG portion of the California Medical Association course at Pebble Beach?" was used only as an entry question. The data will not be considered in the analysis.

In response to Question No. 2. - "Did you have any information of the method of spatial analysis of the electrocardiogram before the course?" two in group I, three in group II, three in group III and one in group IV responded "Yes". Eight in group I, seven in group II, seven in group III and nine in group IV responded "No".

For those responding "Yes" to Question No. 2 "Where did you obtain this information?" one in group I responded "Book and Journal," one responded "Medical School." In group II two subjects responded "Residency" and one responded "Medical School." In group III one responded "Journal" and one responded to "Book, Journal and Conference, Course and Residency." In group IV one individual responded to "Book, Journal and Course."

In response to Question No. 3. - "Did you feel you have a better understanding of the method of spatial analysis now than before taking the course?"; seven in group I, five in group II, eight in group III, and eight in group IV responded "Yes". Three in group I, five in group II, two in group III, and two in group IV responded "No". Those responding "Yes" to Question No. 3 were asked in 3-A "In what areas

do you feel you have a better understanding?" two subjects in group I, two subjects in group II, one subject in group III responded that they had a greater understanding of electrocardiograms. One subject in group I, one subject in group II, three subjects in group III and three subjects in group IV responded that they had a greater understanding of the derivation of the basic electrocardiogram. Two other categories were used for the coding of responses to the question "Other". The first category was a greater understanding of spatial relationships. The second category - a greater understanding of vector derivations. Three subjects in group I, one subject in group II, two subjects in group III responded they had a greater understanding of spatial relationships. One subject in group I and one subject in group II, one subject in group III and three subjects in group IV responded they had a greater understanding of the vector derivations. One subject in group III responded to both a greater understanding of electrocardiograms and a greater understanding of the derivation of the basic electrocardiogram, and one subject in group IV responded to a greater understanding of the derivation of the basic electrocardiogram and a greater understanding of vector derivations. In response to the Question 3-B "What do you think are some of the reasons for this?" the coding was divided for this open-ended question into positive responses and negative responses. The positive responses are as follows: (a) The course and use of information (b) Simple, clear explanation (c) The relationships between the electrocardiogram and space. The negative responses were as follows: (a) Forgot the

mechanics for plotting vectors (b) No interest (c) Poor instruction (d) No practical value, and (e) Brief exposure.

The positive responses were as follows: Three subjects in group I, five subjects in group II, one subject in group III and three subjects in group IV felt the reason was the course and the use of the information. Two subjects in group III and three subjects in group IV felt that the reason was the simple, clear explanation. Three subjects in group I, one subject in group III and one subject in group IV felt that the reason was that they could see the relationships between the electrocardiogram and space. One subject in group IV responded to both the course and the use of the information and the simple, clear explanation.

Responses that were negatively directed in Question No. 3-B were as follows: Two subjects in group I and one in group IV responded that they forgot the mechanisms for plotting. One individual in group II and one individual in group IV stated "No interest." One individual in group II stated "Poor instruction." Two individuals in group II indicated the response "No practical value." One individual in group I indicated both "No practical value" and "Brief exposure" for their answer in Question No. 3.

In answer to Question No. 4 - "Has this course in Spatial Analysis affected your interest in the interpretation of electrocardiograms?" four in group I, two in group II, five in group III and three in group IV responded "Yes". Six in group I, eight in group II, five in group III and seven in group IV responded "No".

For those responding "Yes", a question, 4-A, was posed - "In what way has your interest been affected?" The coding for this open-ended question is as follows:

a. Interest created

b. Taking further course

c. Can now better understand the electrocardiograms.

Four subjects in group I, one subject in group III and one subject in group IV responded that interest was created. One individual in group II and one individual in group I stated they were taking further courses. One individual in group II, three individuals in group III and one individual in group IV stated that they could now better understand electrocardiograms.

Those subjects responding to interview item 4-A were asked "How does the course accomplish this?" Answers were coded as follows: (a) Exposure to information and (b) Teaching methods and presentation. One individual in group I and one individual in group IV responded "Exposure to information." Two individuals in group II, four individuals in group III and one individual in group IV responded "Teaching methods and presentation."

For those individuals responding to Question No. 4 with "No", Question 4-B was used, which read "If no, have you any reasons for this?" The responses to this question were coded as follows: (a) Major interest already (b) Never do electrocardiograms (c) Rarely do electrocardiograms (d) Not of interest or value to the general practitioner (e) Application was not explained.

Two subjects in group II, three subjects in group III, two subjects in group IV responded this was their major interest already. Two in group I responded that they never do electrocardiograms. One in group I responded that he rarely does electrocardiograms. Three in group I, two in group II, one in group III and four in group IV responded that the subject was not of interest or value for the general practitioner. Four in group II, one in group III, and one in group IV responded that the application was not explained.

In response to Question No. 5 - "Have you sought further information about spatial analysis of the electrocardiogram since taking the course?" those replying "Yes" were two from group I, four in group II, two in group III and three in group IV. Those replying "No" were eight in group I, six in group II, eight in group III and seven in group IV. For those participants responding "Yes" they were asked Question 5-A, "From what source have you sought this information?" Two subjects in group I, two subjects in group II, one subject in group III responded "Reading." One subject in group II and one subject in group IV responded "Course." One subject in group II and one subject in group III responded both "Reading and Colleague." One subject in group IV responded "Reading, Conference and Colleague" and another subject in group IV responded "Reading and Course."

In response to Question No. 6 - "What type of useful information do you feel you obtained as a result of taking the course?" Those responses under "Other" were further coded as (c) Exposed area of ignorance (d) Better understanding of vectors, reports and

space and (e) Learned about instructional methods.

The responses to Question No. 6 are as follows: three subjects in group I, three subjects in group II, three subjects in group III and three subjects in group IV responded to a - Plotting vectors. Six subjects in group I, four subjects in group II and three subjects in group IV responded "None." One subject in group II and three subjects in group III and three subjects in group IV responded, "Exposed area of ignorance." One subject in group II, three subjects in group III and one subject in group IV responded, "They have a better understanding of vectors reports and space." One subject in group I and one subject in group III responded, "They learned about instructional methods."

In response to Question No. 7 - "Before the course, did you do electrocardiograms on your patients in your office or did you send the patients to an ECG laboratory?" One in group I stated that he does both routinely. Four in group I, seven in group II, seven in group III, and seven in group IV used "the Lab" and one in group I did not do electrocardiograms.

In response to Question No. 7-A for those that responded, for office, "What do you do with the electrocardiogram tracings?" five subjects in group II, seven subjects in group III and two subjects in group IV responded that they "reviewed tracing and write a report." Two subjects in group I responded that they both "review the tracing and write a report and send a tracing to the cardiologist." Two subjects in group I and two subjects in group II responded that they both "review the tracing only, no written report and send the tracing to a

cardiologist." One individual in group III responded he "used the tracing only with no written report and reviews the tracing and writes a report." One individual in group I, two individuals in group II and four individuals in group IV responded that "they send the tracing to a cardiologist." Of those that send the tracing to the cardiologist five in group I, one in group II, four in group IV "read the report and reviewed the electrocardiogram," one subject in group IV just "read the report and reviewed the electrocardiogram."

For those that responded "Lab." to Question 7 , Question 7-B "What did you do when the electrocardiogram was returned?" was asked of them. One in group I. two in group II just "read the report." Three in group I, one in group II, two in group III and one in group IV "read the report and reviewed the electrocardiogram." Two in group IV stated, "not seen."

In response to the Question No. 8, "Since the course, are you doing electrocardiograms on your patient in your office or are they sent to the laboratory?" four in group I, seven in group II, eight in group III and seven in group IV responded "Office." Three in group I, three in group II, two in group III, three in group IV responded that they "sent their electrocardiograms to the laboratory," and one person in group I "does not do electrocardiograms." One subject in group I does "both routinely."

In response to Question No. 8-A: for those that responded for office, "What do you do with the ECG tracings?" five subjects in group II, seven subjects in group III and four subjects in group IV re-

sponded that they "reviewed tracing and write a report." Two subjects in group I responded that they both "review the tracing and write a report and sent the tracing to a cardiologist." Two subjects in group I and one subject in group II responded that they both "review the tracing only with no written report and send the tracing to a cardiologist." One individual in group III responded he used the "tracing only with no report and reviews the tracing and writes a report." One individual in group I, two individuals in group II and four individuals in group IV responded that they "send the tracing to a cardiologist." Of those that send the tracing to the cardiologist five in group I, one in group II, three in group IV "read the report and reviewed the electrocardiogram." One subject in group IV just "read the report or read the report and reviewed the electrocardiogram." For those that responded "Lab" in Question No. 7, Question 8-B "What did you do when the electrocardiogram was returned?" was asked of them. Four in group I, two in group II, two in group III and one in group IV "read the report and reviewed the electrocardiogram." Two in group II and one subject in group IV stated "Not seen." One subject in group IV stated "Not seen and refers patients with cardiac problems to a cardiologist."

When comparing questions 7 and 8, the researchers find no changes in behavior. When comparing 7-A and 8-A, it was found that one subject in group IV changed from the response to Question 7-A, "sending the electrocardiogram to a cardiologist and just reading the report and reviewing the electrocardiogram" to the response 8-A "reviewing the tracing and writing a report himself."

When comparing Questions 7-B and 8-B one individual in group I and two individuals in group II changed their response from just "reading the report" in 7-B to "read the report and reviewed the electrocardiogram" in Question 8-B.

DISCUSSION

In asking the physician if there was any change in his behavior, as a result of the course (Question 6 in the Wilson's disease interview form and Questions 7 and 8 in the Electrocardiology interview form) there is a problem of some prestige bias. We do not know whether the physician did respond with a truthful answer and if there has been an actual change in his behavior, if he perceived a change in his behavior, and would admit a change in behavior or would be reluctant to admit previous lack knowledge on the subject. Filter questions were not able to be formulated that would allow low prestige answer obtaining data on changes in behavior. Meeting the proglems, as shown above, obtaining a truthful answer from the respondent was felt to be very serious deficiency in the interview methodology.

In attempting to obtain by interview data about how information from courses is being used in the practice of medicine, one can see that serious problems are encountered. If the physician doesn't perceive any behavioral change when there is a change in the practice of his medicine, he will not indicate he is doing anything differently. If the physician feels the interviewer is looking for change, he may provide data indicating behavioral changes when in fact there are none. The physician may be reluctant to admit previous lack of knowledge on the subject and therefore will not state that he is doing anything differently in the practice of medicine.

In referring to the Electrocardiology interview form analysis,

in response to Question No. 3 -"Do you feel you have a better understanding of the method of spatial analysis now than before taking the course?" it was found that seven of ten in group I, five of ten in group II, eight of ten in group III, and eight of ten in group IV responded "Yes," yet, in comparing Question 7-A and 8-A it was found that only one subject in group IV stated a behavioral change and when comparing questions 7-B and 8-B, one individual in group I and two individuals in group II indicated a behavioral change.

From the Wilson's disease interview form in response to the question No. 2 "Do you feel you have a better understanding of Wilson's disease now than before taking the course?" all of the subjects interviewed for each of the three groups indicated they felt they had a better understanding. In response to question #6, "Are you doing anything different in your work?" three of group A indicated "Yes," one of group B indicated "Yes," and four of group C indicated "Yes."

As investigators, we only know that the subject stated they perceived a change in their behavior. We do not have objective data such as a pre-and a post observation and evaluation form providing objective data about the subject's behavior in the office with relationship to his dealing with the electrocardiogram or the suspect patient with Wilson's disease.

The investigators do understand that the question "Are you doing anything different in your work?" tended to be a leading question for the Wilson's disease group; thus we do not have data to show the subject was not responding in a manner to please the interviewer.

For those responding "No," we do not know whether the subject felt a "Yes" answer would or would not indicate a previous ignorance or a lower level of patient medical care and thus would not be a socially acceptable answer for that subject. Also, the subject may not have been percepting a change in their behavior in the practice of medicine. Many questions are raised as a result of the use of an interview instrument to obtain data on how information is used and applied by the physician to the practice of medicine.

CONCLUSION

The interview methodology leaves much data open for interpretation since the responses are attitudinal responses and do not provide objective data; therefore, it is recommended that the methodology not be used to gather data on how knowledge learned by the physicians from these courses is applied to medical practice.

It is suggested that a methodology be developed which would use pre-and post observation of behaviour and a series of standardized simulated patients as pre-and posttest with a high predictive level for patient-management to obtain data on how knowledge is applied to medical practice.

FINAL REPORT
U.S. PUBLIC HEALTH GRANT
PH 108 66 263

PART II - APPENDEXES

PART II

APPENDEXES

APPENDIX - A

A
Programmed Text
on
Spatial Analysis of the
Electrocardiogram

Spatial Analysis of the Electrocardiogram*

This programmed text is designed to teach spatial analysis of any electrocardiogram. It has been developed at the University of Southern California School of Medicine, Department of Electrocardiography, Los Angeles, California, by:

Irwin Hoffman, M.D.

Julien H. Isaacs, M.D.

James V. Dooley, M.D.

Phil R. Manning, M.D.

and

Donald A. Dennis, M.A.
Programming Consultant

Preface

The method of *Spatial Analysis* of an unknown electrocardiogram will be presented step by step utilizing a question and response format. Each question will present an introductory statement followed by (a) a specific illustration and (b) a question requiring utilization of this information. A number of questions will review the same information in a different manner for reinforcement. *The programming will lead the reader step by step to an understanding of spatial analysis despite selection of incorrect responses.*

179 A

Table of Contents

Introduction

The normal heart is activated region by region. The interventricular septum is depolarized prior to any other region of the ventricles. The activation wave front passes progressively from the interventricular septum to the anterior wall; the anterior wall completes activation prior to the lateral wall; the lateral wall completes activation prior to the posterior wall. The inferior regions of both ventricles are activated prior to the superior or basilar regions. The normal activation wave front, therefore, has a specific directional sequence in space.

A pathophysiologic change in the heart, hypertrophy, block or infarction, produces abnormal changes in the electrocardiogram by altering this sequence of regional activation or by changing the electrical field produced by an involved region of the heart.

The standard electrocardiogram reflects these changes in the activation sequence of the heart. This program will develop a method of Spatial Analysis for any electrocardiogram.

Prerequisites

The following information is basic to the understanding and completion of the material included in the forthcoming program:

I. Elementary knowledge of the anatomy of the heart.

II. Ability to identify the various electrocardiographic complexes: P, QRS, and T.

III. An understanding of the terms: left-right, superior-inferior, and anterior-posterior in relation to the heart as it is located in the chest.

Course Goal

At the completion of this course you will be able to determine mean P, QRS, and T vectors in space utilizing the method of spatial analysis.

Instructions

Read each question and select the best answer. Turn to the page number listed immediately after your response. This page will indicate whether you are correct or incorrect and will provide an explanation of your response. After each explanation there will be further instructions for proceeding.

If you selected an incorrect answer, you must return to the original question and select the correct answer before you can proceed to the next question.

Please turn to page 1

An upright deflection, an R wave, in any lead of the electrocardiogram represents forces moving toward the positive electrode of that lead. Lead I is a bipolar lead with its positive electrode located on the left arm and its negative electrode on the right arm.

An R wave in lead I, therefore, must represent QRS forces moving toward the:

LEFT ARM page 4

RIGHT ARM page 2

From Page 1

Your answer, RIGHT ARM, is incorrect.

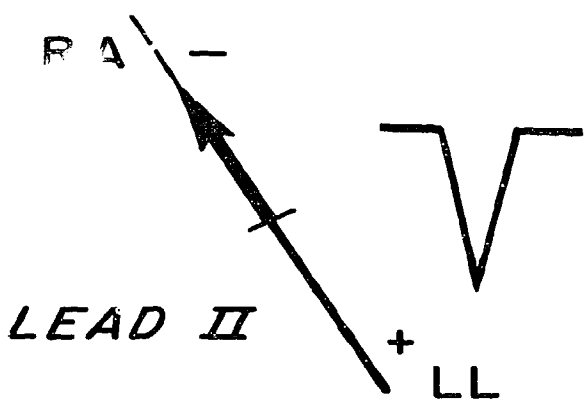
The positive electrode of lead I is located on the left arm. An upright deflection in any lead must represent forces moving toward the positive electrode of that lead. Forces moving toward the right arm are moving away from the positive electrode of lead I and must give rise to a negative deflection.

Return to page 1 and choose the correct answer.

From Page 8

Your answer, RIGHT ARM, is incorrect.

The positive electrode of lead II is located on the left leg. An upright deflection, an R wave, in any lead must represent QRS forces moving toward the positive electrode of that lead. Forces moving toward the right arm, therefore, must give rise to a negative deflection in lead II.



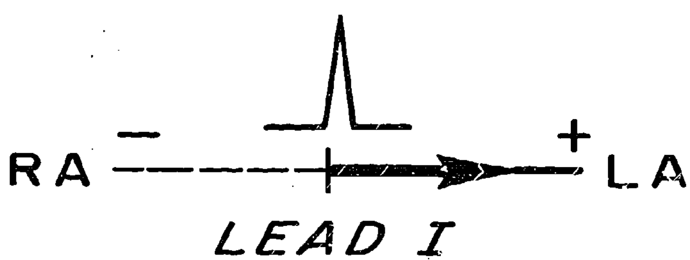
Return to page 8 and choose the correct answer

From Page 1

Your answer, LEFT ARM, is correct.

The positive electrode of lead I is located on the left arm. An upright deflection in any lead represents forces moving toward the positive electrode. An upright deflection in lead I, therefore, must represent QRS forces moving toward the positive electrode and, hence, toward the left arm.

This is the *fundamental assumption for understanding Spatial Analysis.*

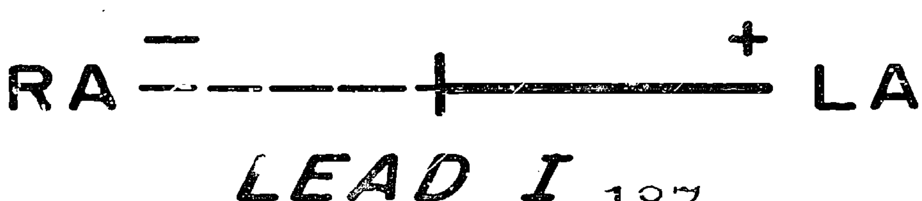


2

An upright deflection, an R wave, in any lead of the electrocardiogram represents QRS forces moving toward the positive electrode of that lead. A negative deflection, a Q or an S wave, in any lead represents forces moving away from the positive electrode of that lead.

A negative deflection, an S wave, in lead I, therefore, must represent QRS forces moving toward the:

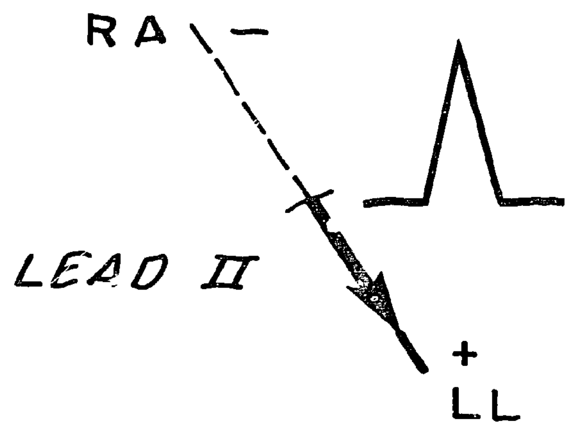
LEFT ARM	page 6
RIGHT ARM	page 8



From Page 8

Your answer, LEFT LEG, is correct.

The positive electrode of lead II is located on the left leg. An upright deflection an R wave in lead II, represents forces moving toward the positive electrode and, hence, toward the left leg.



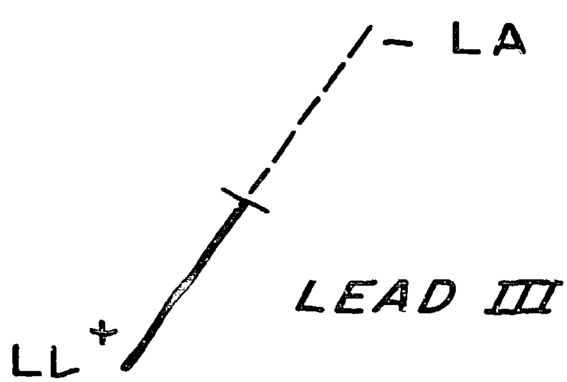
4

Lead III is a bipolar lead with its positive electrode located on the left leg and its negative electrode on the left arm.

A negative deflection, an S wave, in lead III must represent QRS forces moving toward the:

LEFT ARM page 7

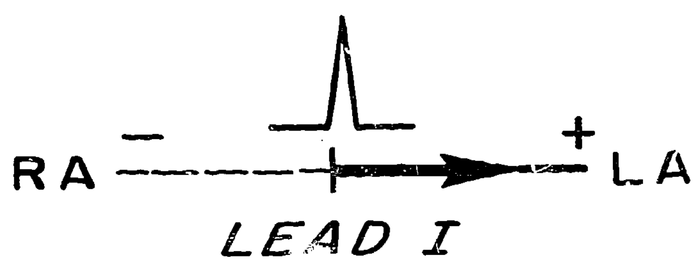
LEFT LEG page 9



From Page 4

Your answer, LEFT ARM, is incorrect.

Forces moving toward the left arm are moving toward the positive electrode of lead I and must give rise to an upright deflection, an R wave, in lead I. A negative deflection or S wave cannot represent forces moving leftward.

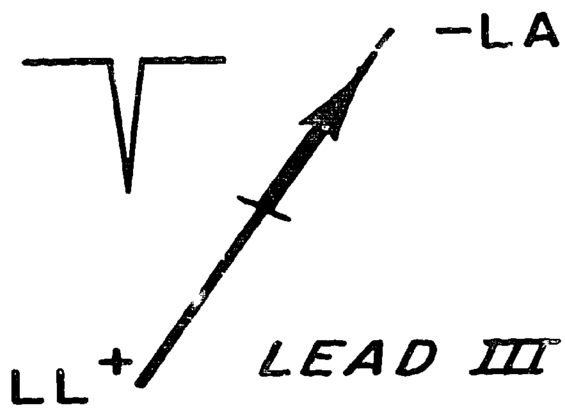


Return to page 4 and choose the correct answer.

From Page 5

Your answer, LEFT ARM, is correct.

The positive electrode of lead III is located on the left leg. An S wave must represent QRS forces moving away from the positive electrode and hence toward the left arm.

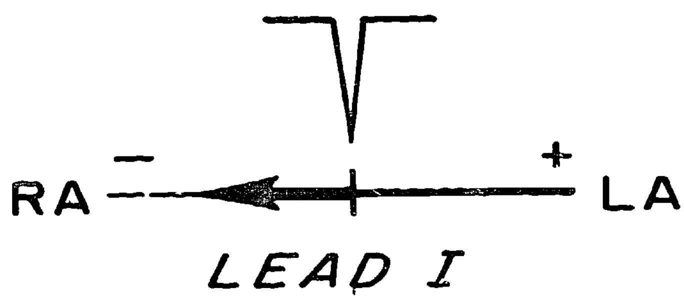


Continue reading on page 10.

From Page 4

Your answer, RIGHT ARM, is correct.

A negative deflection, an S wave, represents QRS forces moving away from the positive electrode. Since the positive electrode of lead I is located on the left arm, an S wave must represent forces moving away from the positive electrode and, hence, toward the right arm.



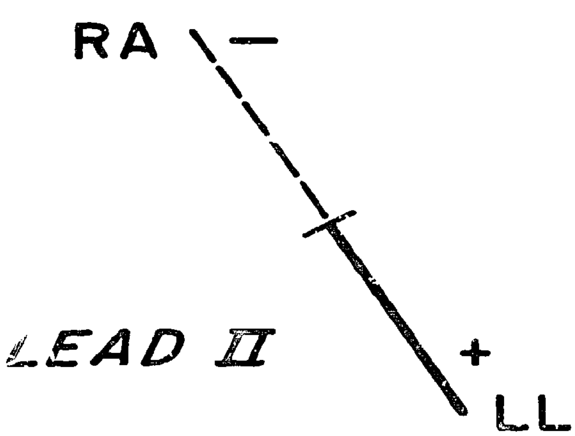
3

An upright deflection, an R wave, in any lead represents QRS forces moving toward the positive electrode of that lead. Lead II is a bipolar lead with its positive electrode located on the left leg and its negative electrode on the right arm.

An R wave in lead II must represent QRS forces moving toward the:

LEFT LEG page 5

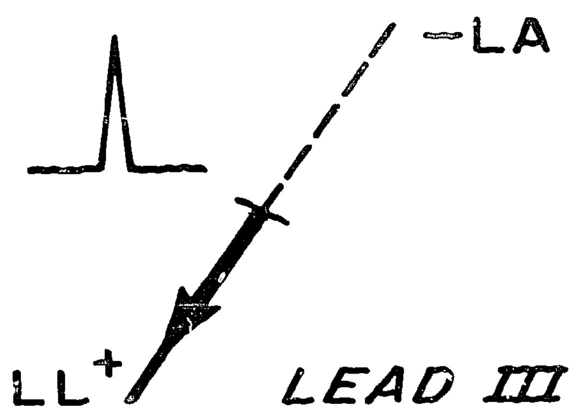
RIGHT ARM page 3



From Page 5

Your answer, LEFT LEG, is incorrect.

The positive electrode of lead III is located on the left leg. Forces moving toward the positive electrode must give rise to an upright deflection, an R wave, in that lead. An S wave, therefore, cannot represent forces moving toward the left leg.

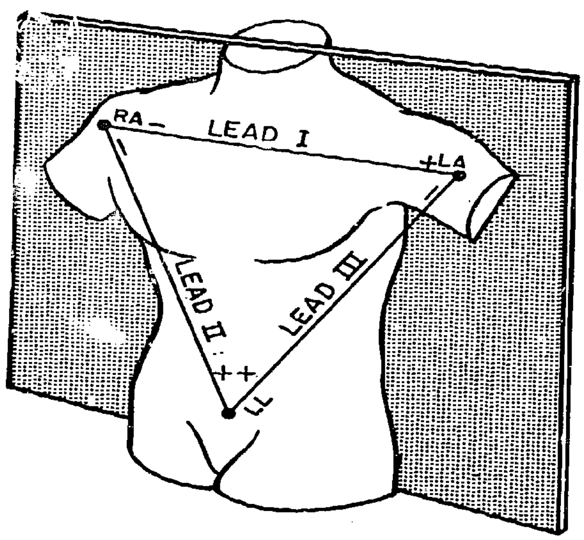


Return to page 5 and choose the correct answer.

From Page 7

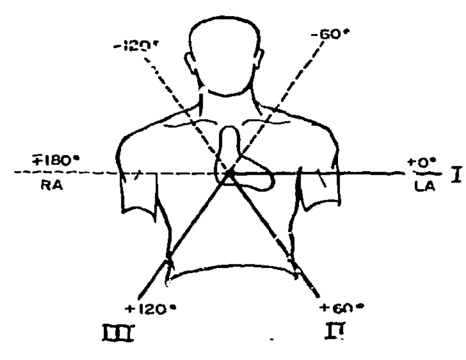
Extremity leads I, II and III are bipolar leads. Each lead has its own positive and negative electrodes which may be affixed anywhere on the extremities.

The *effective locations* of the right and left arm electrodes are at the shoulders and the effective location of the left leg electrode is at the symphysis pubis. Lines joining these effective electrode locations, at the shoulders and at the symphysis pubis, result in an equilateral triangle known as the Einthoven Triangle. The three lines of the Einthoven Triangle comprise the *axes of extremity leads I, II, and III.*



5

For *Spatial Analysis,* the three sides of the Einthoven Triangle, the axes of leads I, II, and III, may be redrawn passing through a common point located in the center of the heart. The direction of each lead in degrees and the locations of the positive electrodes may be added to obtain the *Triaxial Figure.*



TRIAXIAL REFERENCE FIGURE

The spatial location of the positive portion of the lead I axis is:

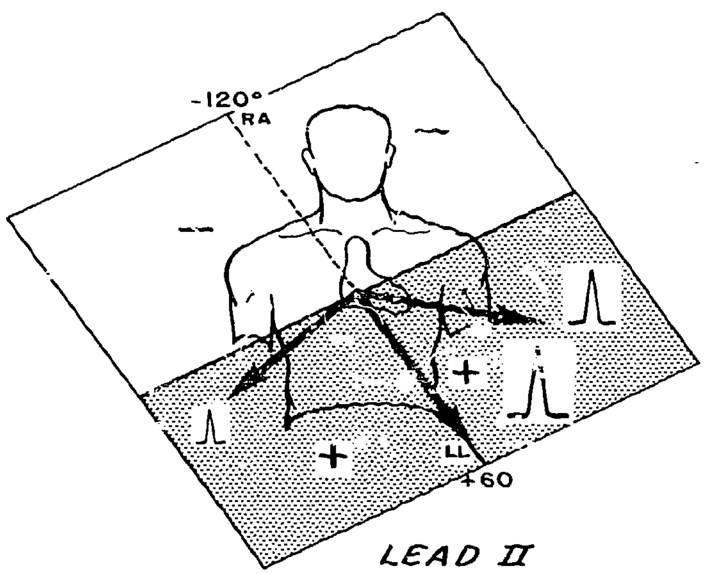
LEFT AT 0° page 12

RIGHT AT 180° page 14

From Page 18

Your answer, AN R WAVE, is incorrect.

An R wave in lead II represents forces lying within the positive field of lead II and not in the negative field.



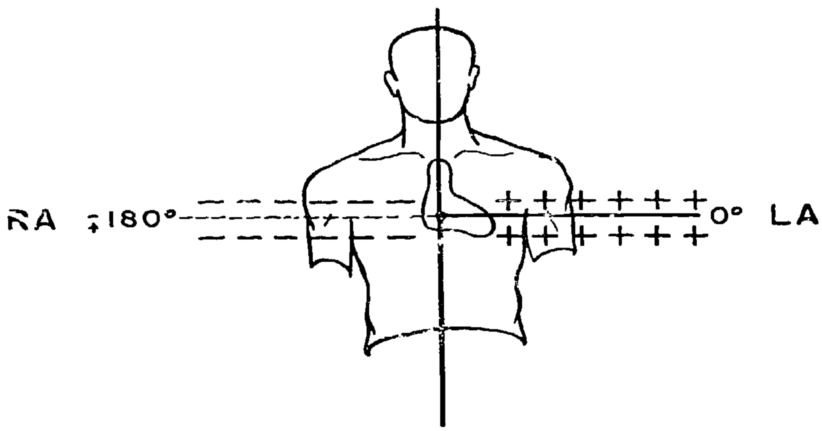
LEAD II

Return to page 18 and choose the correct answer.

From Page 10

Your answer, LEFT AT 0°, is correct.

The axis of lead I may be divided into a positive and a negative portion by a perpendicular line through its center. Since the positive electrode of lead I is located on the left arm, the positive portion of the lead I axis must be on the left side of this perpendicular line at 0°. The negative portion is located rightward at 180°.



LEAD I

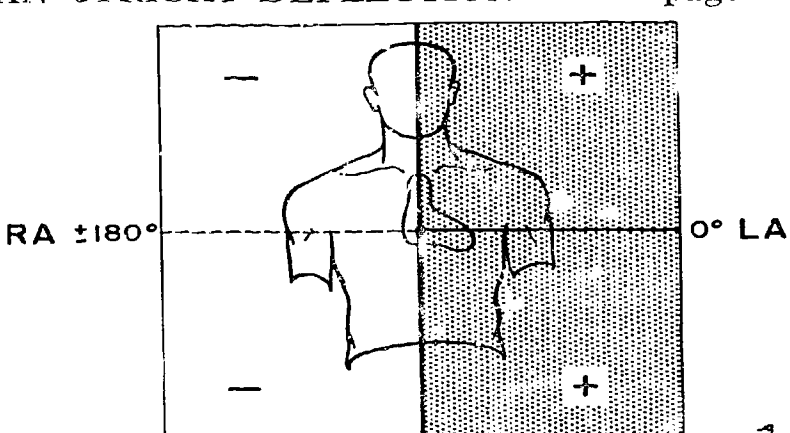
6

The perpendicular line through the center of the lead I axis also divides the body into a positive and a negative portion or *field*.

A QRS force or vector in the positive field of lead I must give rise, in this lead, to:

A NEGATIVE DEFLECTION page 17

AN UPRIGHT DEFLECTION page 15

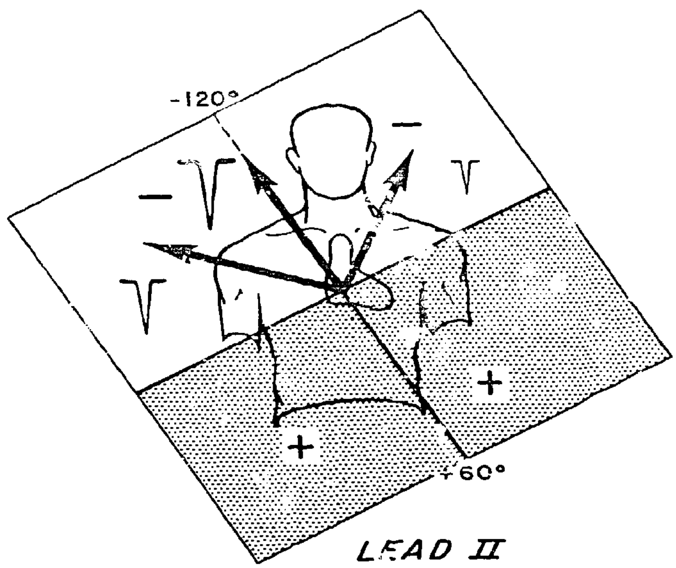


LEAD I

From Page 18

Your answer, AN S WAVE, is correct.

An S Wave in lead II indicates forces are moving toward the negative electrode of this lead. Forces moving toward the negative electrode, therefore, must be located within the negative field of lead II.



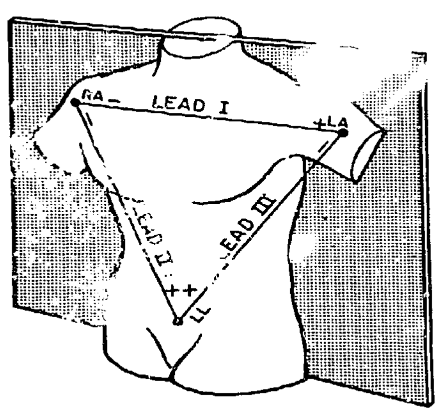
9

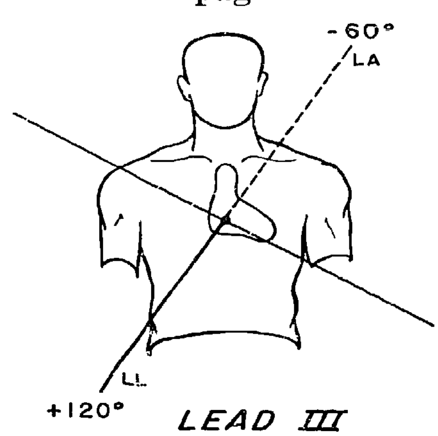
The positive electrode of lead III is located on the left leg and the negative electrode on the left arm. The effective spatial location of the positive electrode is the symphysis pubis and of the negative electrode is the left shoulder.

The spatial location of the positive portion of the lead III axis is:

RIGHT AND INFERIOR AT +120° page 22

LEFT AND SUPERIOR AT −60° page 20

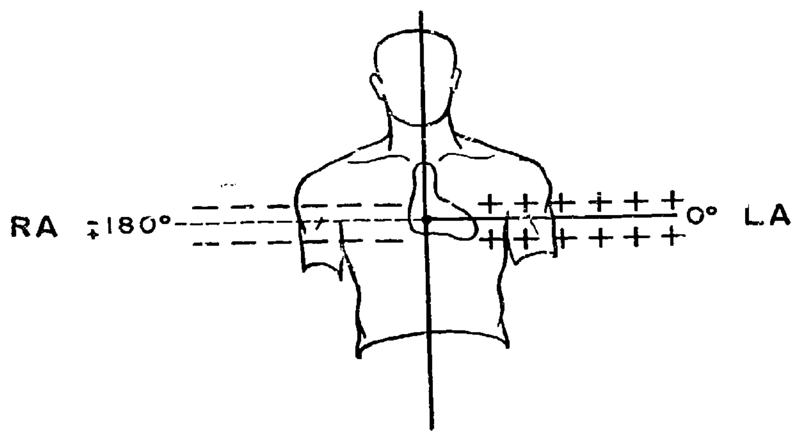




From Page 10

Your answer, RIGHT AT 180°, is incorrect.

The axis of lead I may be divided into a positive and a negative portion by a perpendicular line through its center. To locate the positive portion of the lead I axis rightward at 180° would require placing the positive electrode of lead I *incorrectly* on the right arm.



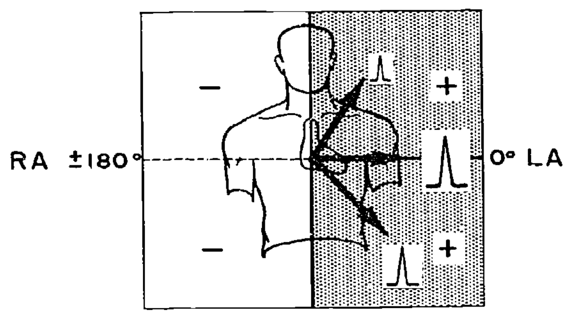
LEAD I

Return to page 10 and choose the correct answer.

From Page 12

Your answer, AN UPRIGHT DEFLECTION, is correct.

A vector lying anywhere within the positive field of lead I must represent forces moving toward the positive electrode of this lead. A vector moving toward the positive electrode of lead I must give rise to an upright deflection.

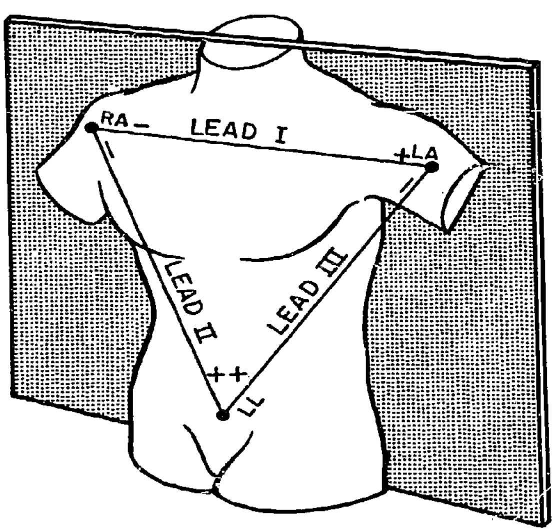


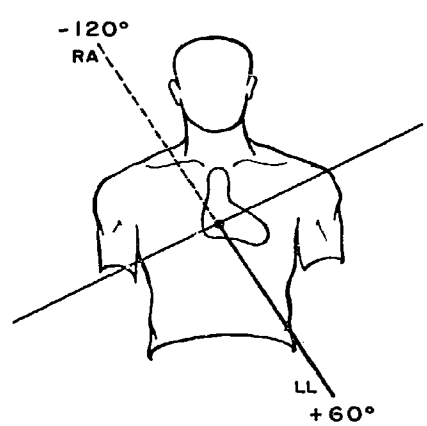
LEAD I

7

The positive electrode of lead II is located on the left leg and the negative electrode on the right arm. The effective spatial location for the positive electrode is the symphysis pubis and for the negative electrode the right shoulder. The location of the positive portion of the lead II axis is:

LEFT AND INFERIOR AT +60°	page 18
RIGHT AND SUPERIOR AT –120°	page 16



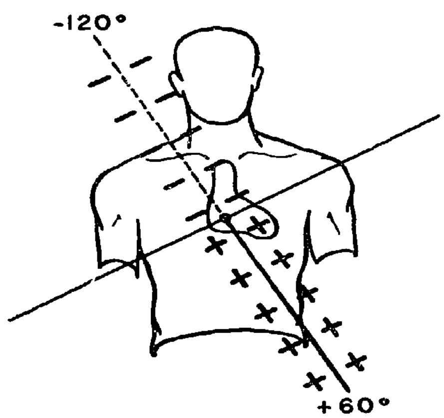


LEAD II

From Page 15

Your answer, RIGHT AND SUPERIOR AT —120°, is incorrect.

The lead II axis may be divided into a positive and a negative portion by a perpendicular line through its center. The positive portion is located on the side of the perpendicular line adjacent to the positive electrode. If the positive portion of the lead II axis were right and superior at —120°, the positive electrode of lead II would be located *incorrectly* on the right arm.



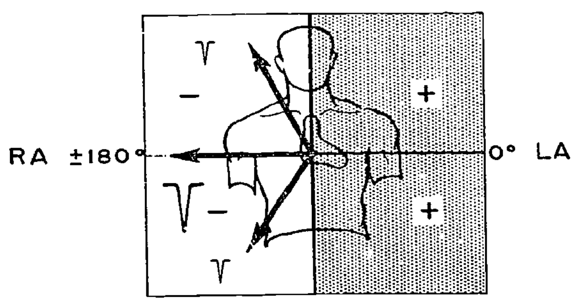
LEAD II

Return to page 15 and choose the correct answer

From Page 12

Your answer, A NEGATIVE DEFLECTION, is incorrect.

A negative deflection, in lead I results from a vector moving toward the negative electrode of this lead. A vector moving toward the nega-tive electrode of lead I must lie in the *negative field.*



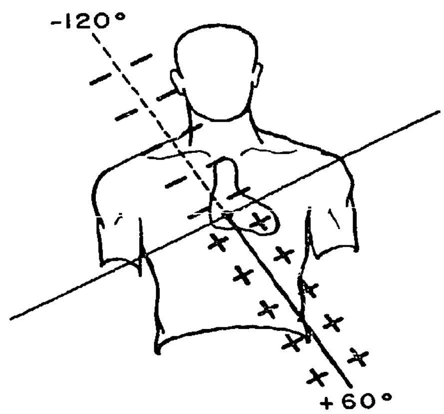
LEAD I

Return to page 12 and choose the correct answer.

From Page 15

Your answer, LEFT AND INFERIOR AT +60°, is correct.

The lead II axis may be divided into a positive and a negative portion by a perpendicular line through its center. The positive portion of the lead II axis is located left and inferior at +60°; the negative portion of the lead II axis is located right and superior at −120°.



LEAD II

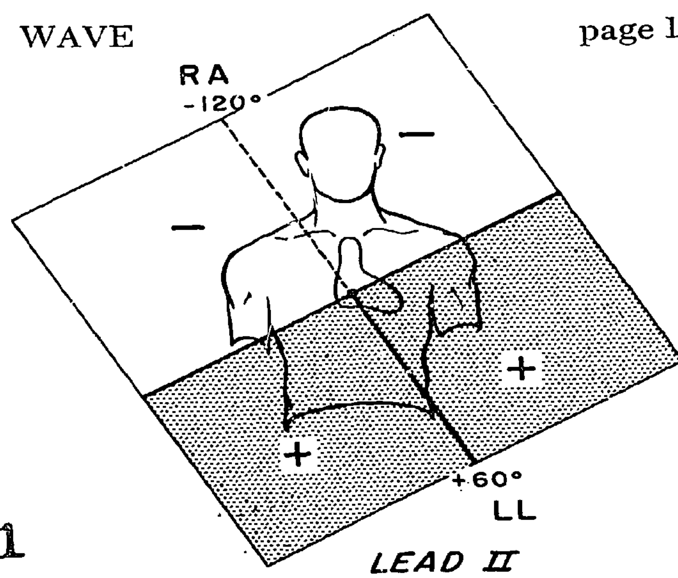
8

The perpendicular line through the center of the le II axis also divides the body into a positive and a negative field.

A vector located in the negative field of lead II must ve rise in this lead to:

AN R WAVE pa ge 11

AN S WAVE page 13

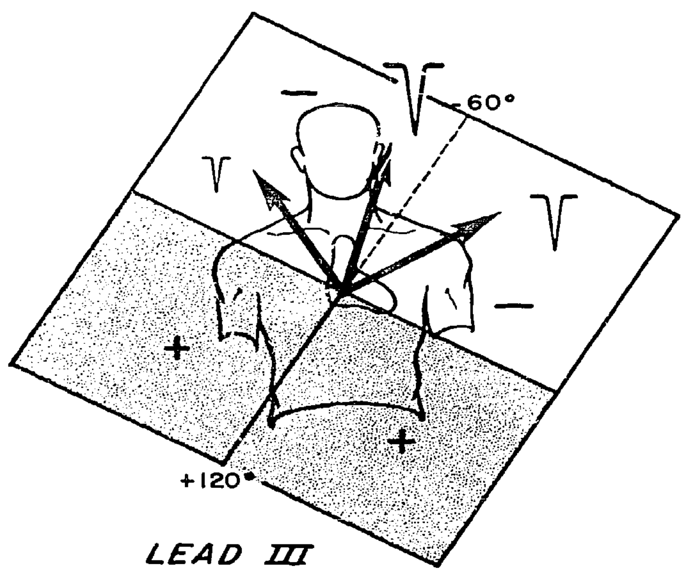


LEAD II

From Page 22

Your answer, A NEGATIVE DEFLECTION, is incorrect.

A negative deflection indicates forces are moving toward the negative electrode. Forces moving toward the negative electrode of lead III are moving toward the left shoulder and, hence, must lie in the negative field of lead III. The negative field of lead III, however, is *not* oriented right and inferior.

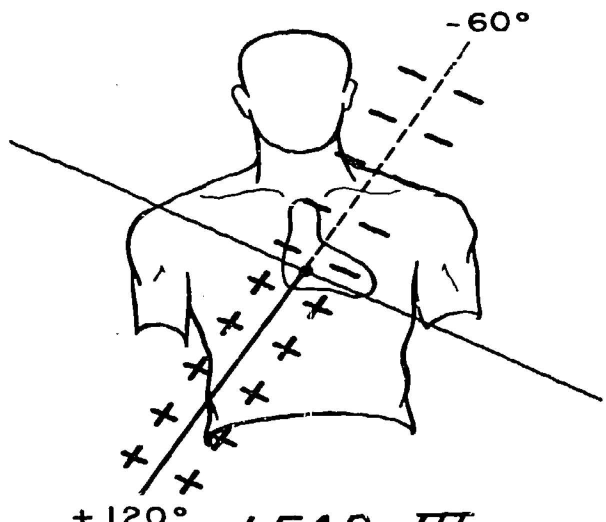


Return to page 22 and choose the correct answer.

From Page 13

Your answer, LEFT AND SUPERIOR AT −60°, is incorrect.

The axis of any lead may be divided into a positive and a negative portion by a perpendicular line through its center. The positive half of the lead axis lies adjacent to the positive electrode. If the positive half of the lead III axis were located left and superior at −60°, the positive electrode of lead III would be located *incorrectly* on the left arm.

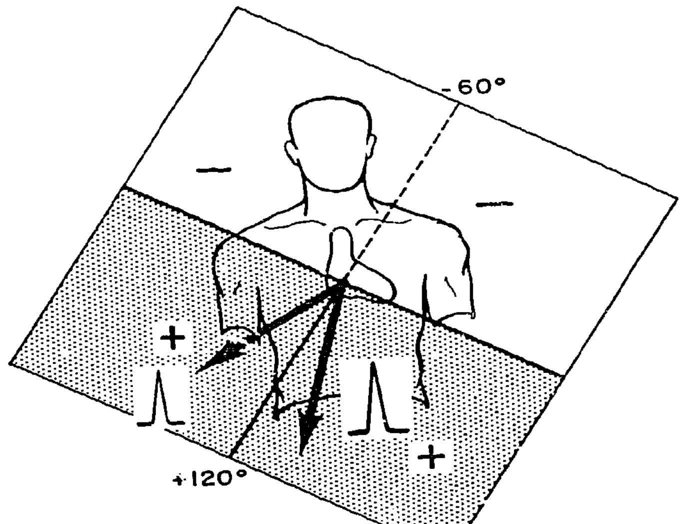


Return to page 13 and choose the correct answer.

From Page 22

Your answer, AN UPRIGHT DEFLECTION, is correct.

An upright deflection in lead III represents QRS vectors moving toward the positive electrode of this lead. Vectors moving toward the positive electrode must lie within the positive field of lead III, which is oriented right and inferior.



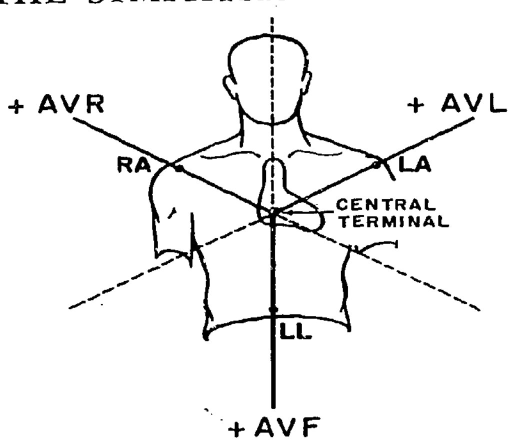
11 *LEAD III*

Extremity leads I, II, and III are bipolar leads each having its own positive and negative electrodes. The *unipolar extremity leads* AVR, AVL, and AVF are recorded with positive electrodes located on their respective extremities. The negative electrode of each unipolar lead is a central terminal assumed to be located within the heart. The effective spatial location of the negative electrode is 180° opposite the positive electrode of each unipolar lead.

The positive electrode of lead AVF is on the left leg. The effective spatial location is the symphysis pubis.

An R wave in lead AVF must represent QRS forces or a *vector* moving:

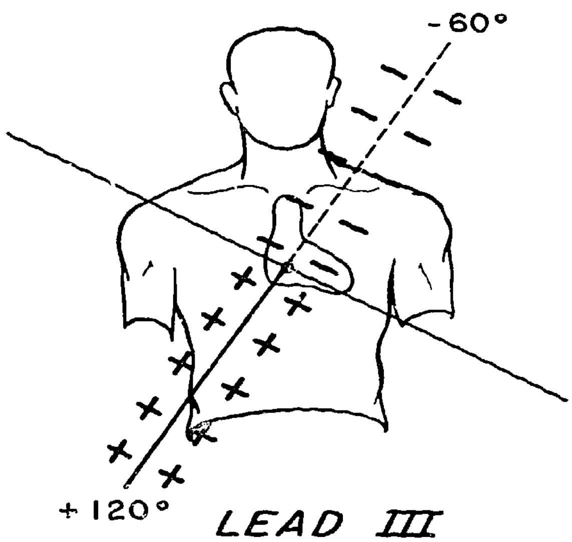
AWAY FROM THE SYMPHYSIS PUBIS	page 29
TOWARD THE SYMPHYSIS PUBIS	page 31



From Page 13

Your answer, RIGHT AND INFERIOR AT + 120°, is correct.

The axis of any lead may be divided into a positive and a negative portion by a perpendicular line through its center. The positive portion of the lead III axis is located in the right and inferior quadrant at +120°; the negative portion is located left and superior at −60°.

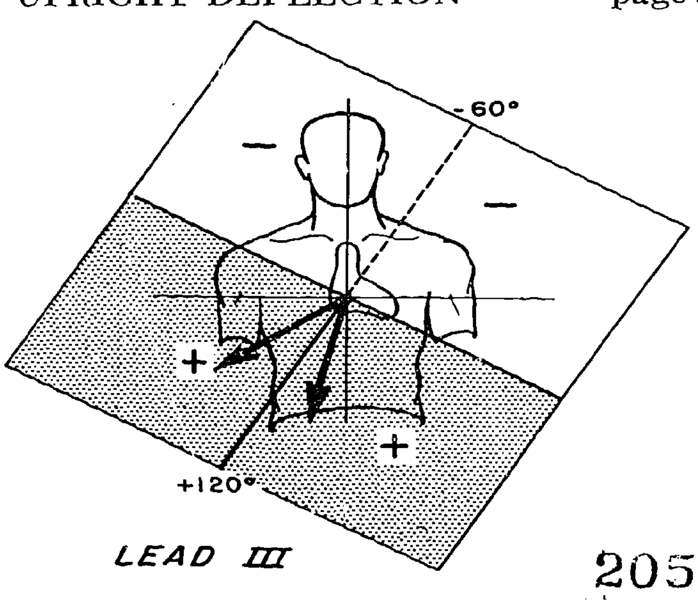


10

The perpendicular line through the center of the lead III axis also divides the body into a positive and a negative field. A vector located right and inferior must give rise in lead III to:

A NEGATIVE DEFLECTION page 19

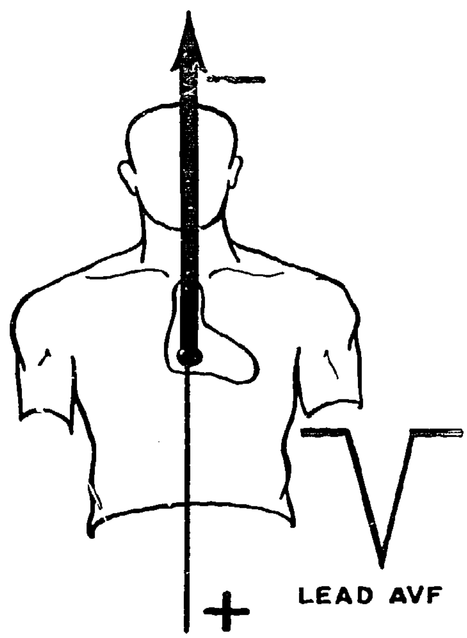
AN UPRIGHT DEFLECTION page 21



From Page 31

Your answer, AN S WAVE, is correct.

The positive electrode of lead AVF is located on the left leg. The effective electrode location is the symphysis pubis. Forces moving toward the positive electrode must give rise to an upright deflection. A vector moving away from the positive electrode and, hence, away from the symphysis pubis produces a negative deflection in lead AVF.



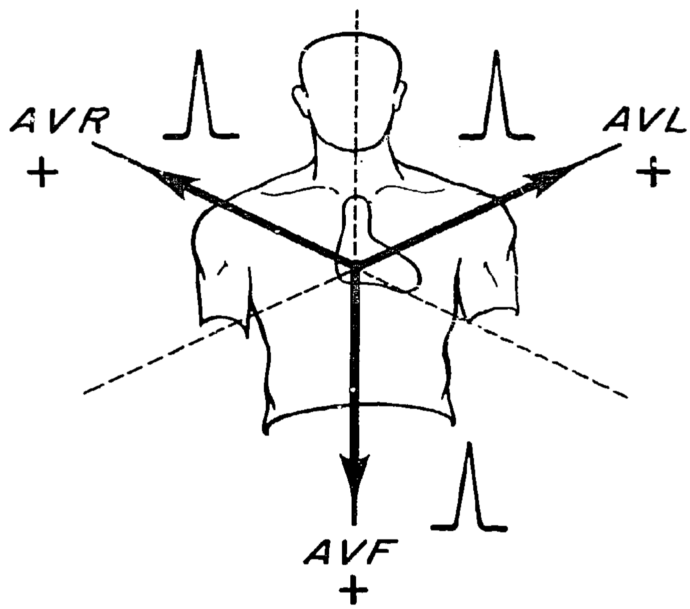
LEAD AVF

Continue reading on pages 24 and 25

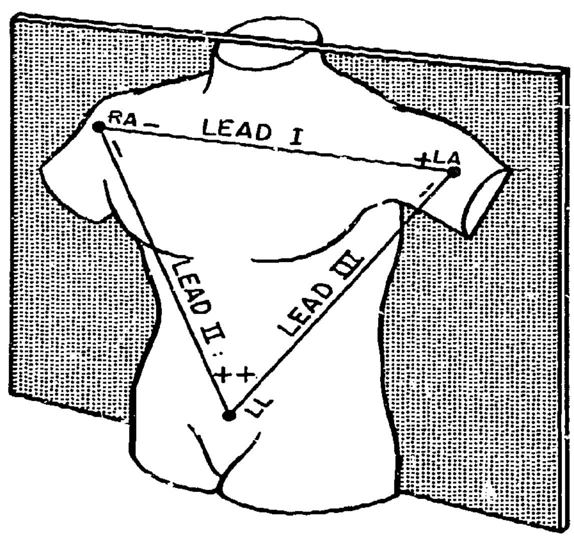
From Page 23

The positive electrode of *lead AVF* is on the left leg and its effective spatial location is the symphysis pubis. An upright deflection, an R wave, in lead AVF indicates vectors moving toward the positive electrode; an upright deflection in lead AVF, then, indicates QRS vectors moving toward the symphysis pubis.

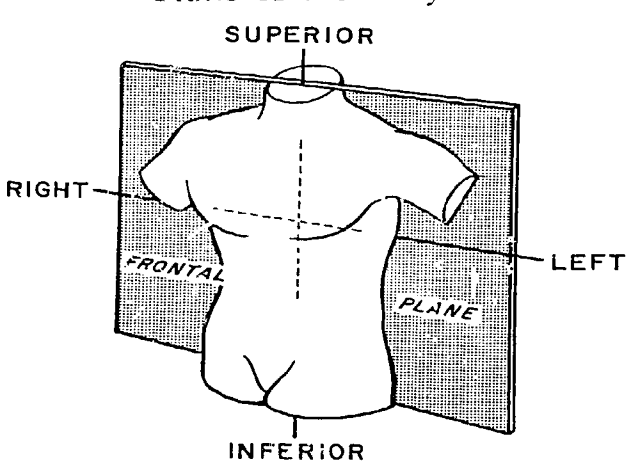
The positive electrode of lead AVL is on the left arm and its effective spatial location is the left shoulder. An upright deflection in *lead AVL* must indicate QRS vectors moving toward the positive electrode of lead AVL and, hence, toward the left shoulder.



The positive electrode of lead AVR is on the right arm. Its effective spatial location is the right shoulder. An upright deflection in *lead AVR* must indicate QRS vectors moving toward the positive electrode of this lead and, hence, toward the right shoulder.



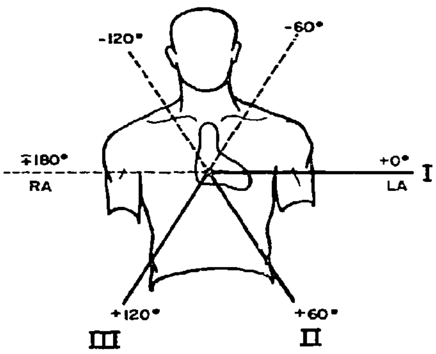
Leads I, II, and III are bipolar leads with electrodes located on the extremities. These leads lie in the *Frontal Plane* of the body.



The Frontal Plane divides the body into a front and back half. It is defined by two axes, *left-right* and *superior-inferior*. Leads AVR, AVL, and AVF are unipolar leads derived from electrodes located on these same extremities and, therefore, also lie in the frontal plane.

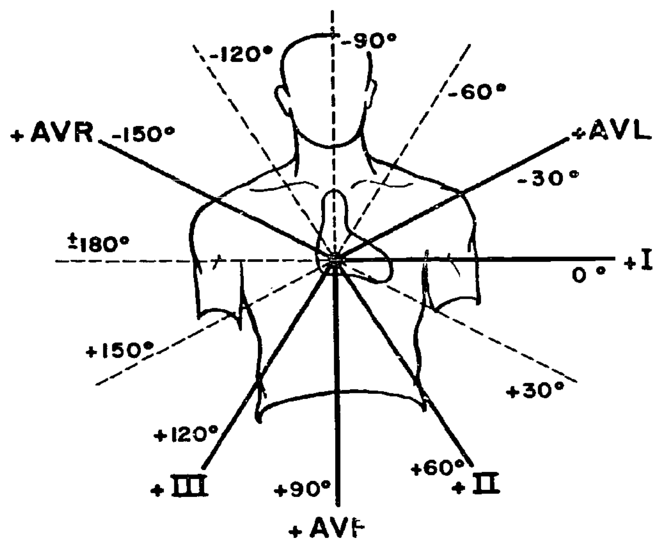
From Page 24

The axes of bipolar leads I, II, and III when drawn through a common point, the center of the heart, produce the triaxial reference figure.



TRIAXIAL REFERENCE FIGURE

Since the unipolar leads AVR, AVL and AVF also lie in the frontal plane, the axes of these leads may be added to the triaxial reference figure. This results in a hexaxial *frontal plane reference figure*. This frontal plane reference figure illustrates the directions and positive poles of the bipolar and unipolar leads.



FRONTAL PLANE

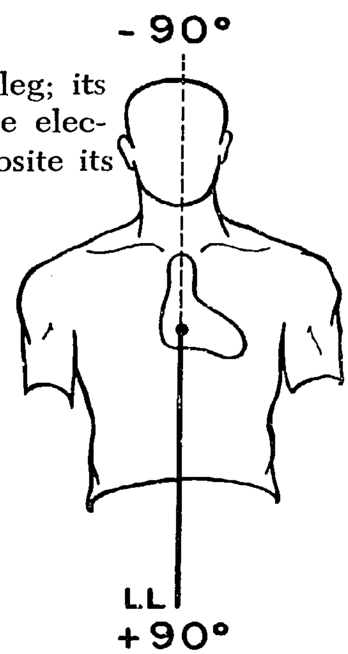
13

The positive electrode of lead AVF is located on the left leg; its effective spatial location is the symphysis pubis. The negative electrode is a central terminal whose spatial location is 180° opposite its positive electrode.

The positive portion of the lead AVF axis is located:

SUPERIOR AT −90° page 28

INFERIOR AT +90° page 30

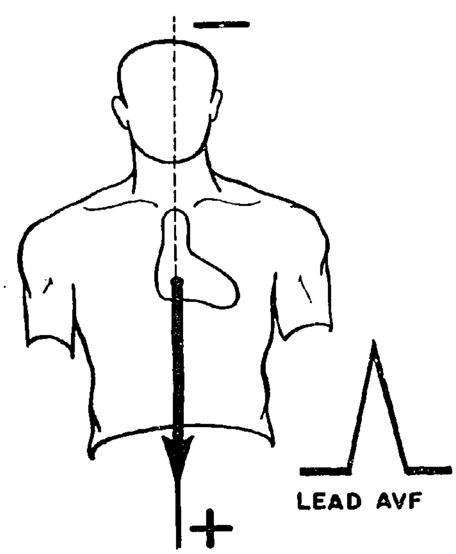


LEAD AVF

From Page 31

Your answer, AN R WAVE, is incorrect.

The positive electrode of lead AVF is located on the left leg. The effective electrode location is the symphysis pubis. Forces moving toward the positive electrode must give rise to an upright deflection. Forces moving away from the symphysis pubis cannot produce an S wave in lead AVF.

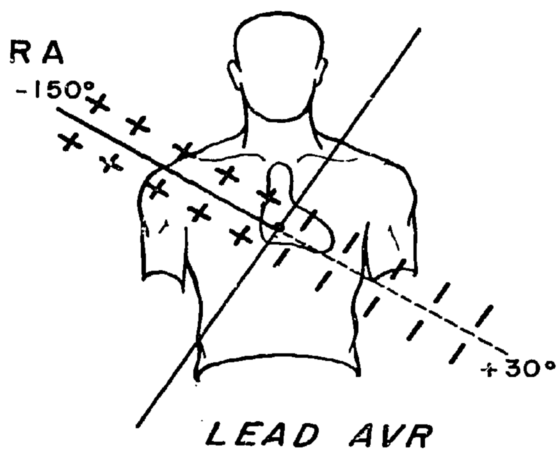


Return to page 31 and choose the correct answer.

From Page 37

Your answer, LEFT AND INFERIOR AT +30°, is incorrect.

The axis of any lead may be divided at its center into a positive and a negative portion. The positive portion of this lead axis is adjacent to the positive electrode; the negative portion is opposite. If the positive half of the lead AVR axis were located left and inferior at +30°, the positive electrode of lead AVR would be located *incorrectly* on the left leg.

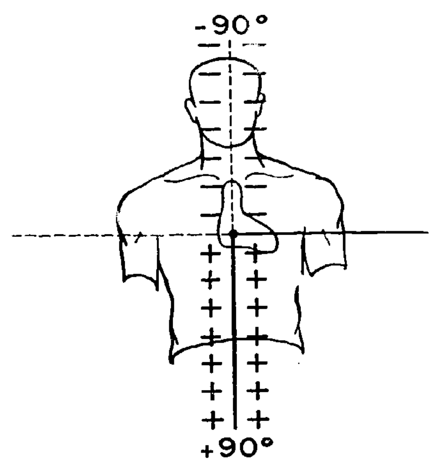


Return to page 37 and choose the correct answer.

From Page 25

Your answer, SUPERIOR AT $-90°$, is incorrect.

The axis of any lead may be divided at its center into a positive and a negative portion. The positive portion of this lead axis lies adjacent to the positive electrode; the negative portion is on the opposite side. To locate the positive portion of the lead AVF axis superior at $-90°$ would require locating the positive electrode *incorrectly* on the head.



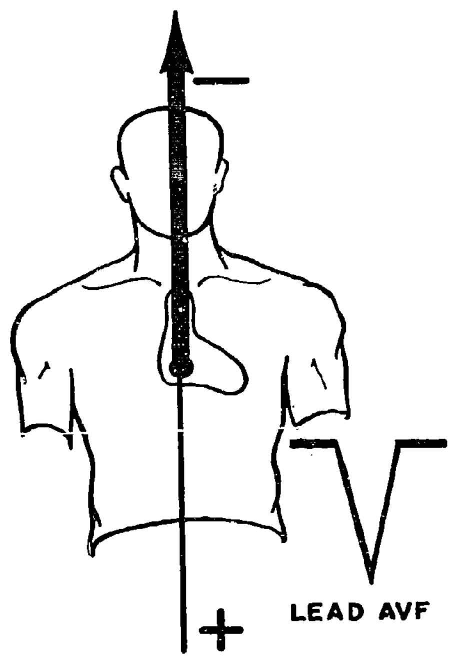
LEAD AVF

Return to page 25 and choose the correct answer.

From Page 21

Your answer, AWAY FROM THE SYMPHYSIS PUBIS, is incorrect.

Forces moving away from the symphysis pubis are directed away from the positive electrode of this lead. Forces moving away from the positive electrode of any lead must give rise to a negative deflection in that lead and, hence, cannot produce an R wave.



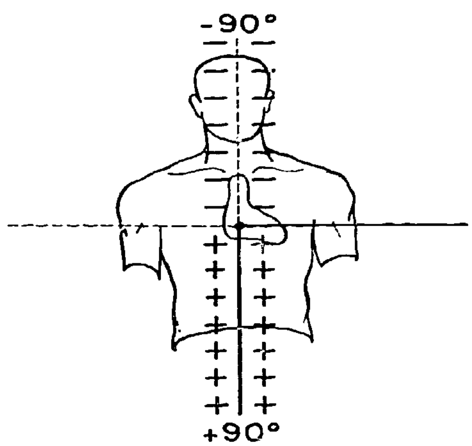
LEAD AVF

Return to page 21 and choose the correct answer.

From Page 25

Yo ır answer, INFERIOR AT +90°, is correct.

The axis of any lead may be divided at its center into a positive and a negative portion. The positive portion of the lead AVF axis lies adjacent to the positive electrode. Since the effective spatial location of the positive electrode of lead AVF is the symphysis pubis, the positive portion of the lead AVF axis must be located inferior at +90°. The negative portion of the lead AVF axis is opposite, superior at −90°.



LEAD AVF

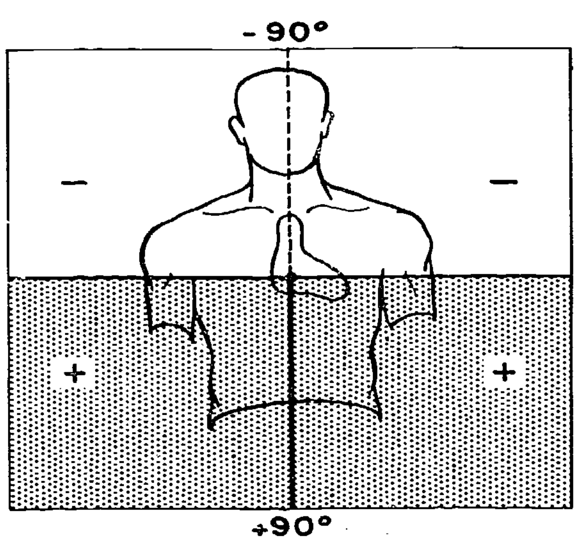
14

The perpendicular line through the center of the lead AVF axis also divides the body into a positive and a negative *field*.

A vector located inferior between 0 and 180° must give rise in lead AVF to an:

S WAVE page 34

R WAVE page 38

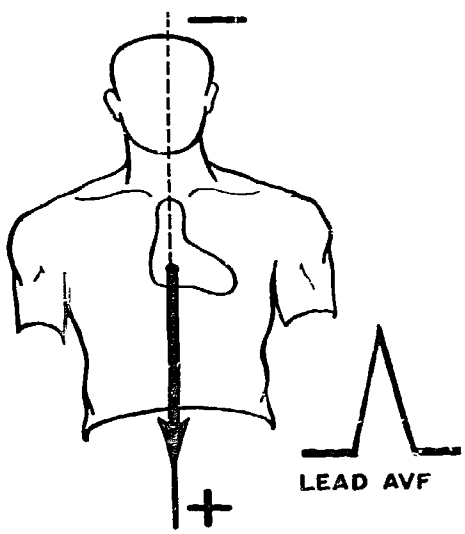


LEAD AVF

From Page 21

Your answer, TOWARD THE SYMPHYSIS PUBIS, is correct.

The positive electrode of lead AVF is located on the left leg. The effective location of this electrode is the symphysis pubis. Forces moving toward the positive electrode are moving toward the symphysis pubis and must give rise to a positive deflection, an R wave, in this lead.

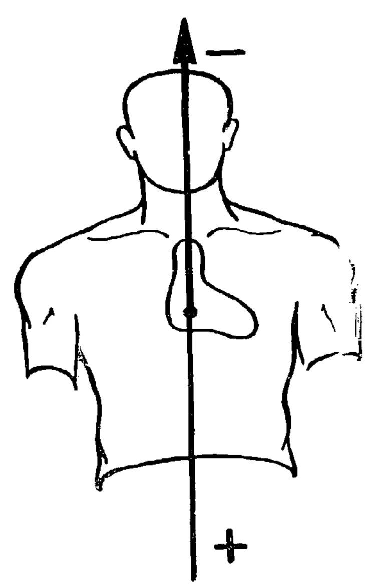


12

A QRS vector directed away from the symphysis pubis produces in lead AVF an:

S WAVE page 23

R WAVE page 26

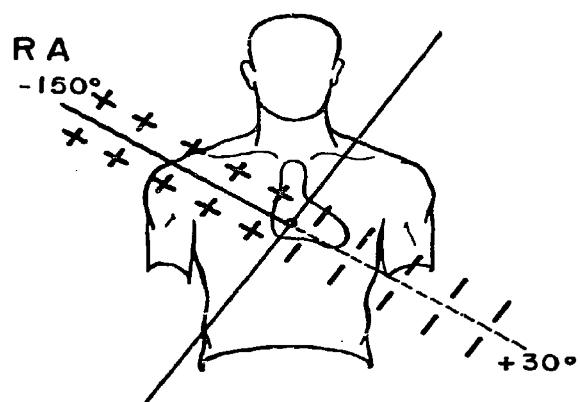


AVF

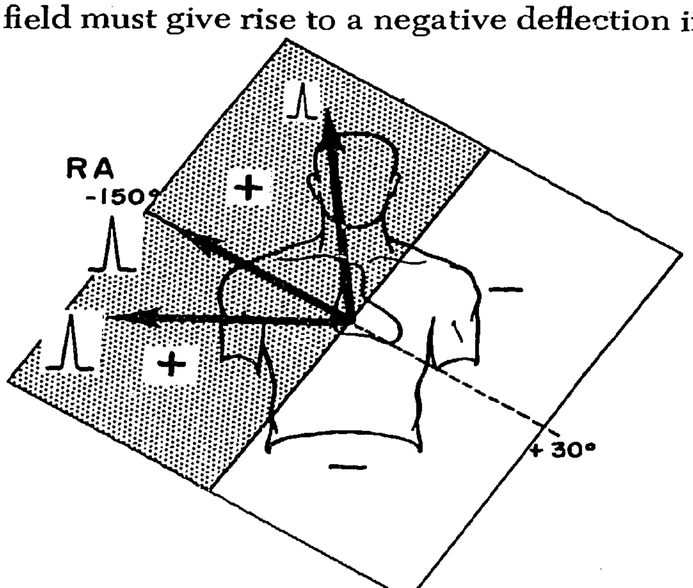
From Page 37

Your answer, RIGHT AND SUPERIOR AT −150°, is correct.

The axis of any lead may be divided at its center into a positive and a negative portion. The positive portion of this lead axis is adjacent to the positive electrode; the negative portion lies on the opposite side. Since the positive electrode of lead AVR is located on the right arm, and its effective spatial location is the right shoulder, the positive portion of the lead AVR axis must be right and superior at −150°.



The perpendicular line through the center of the lead AVR axis also divides the body into a positive and a negative field. A vector lying in the positive field must be moving toward the positive electrode of this lead, and must produce an upright deflection. A vector located in the negative field must give rise to a negative deflection in lead AVR.



LEAD AVR

Continue reading on page 33.

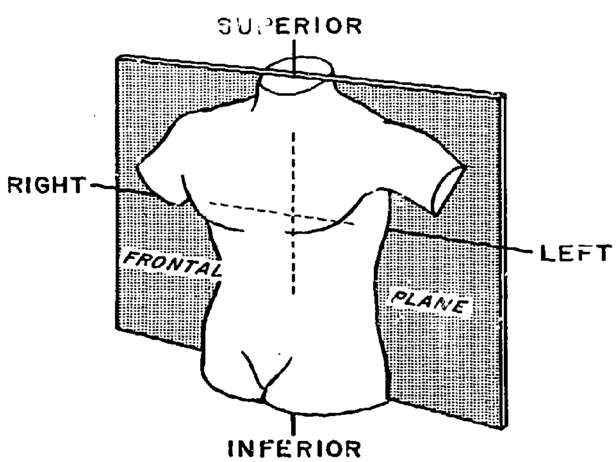
From Page 32

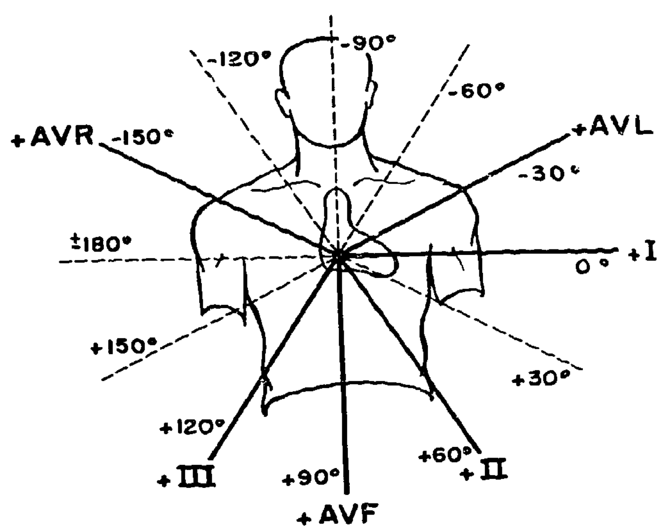
17

Bipolar leads I, II, and III and unipolar leads AVR, AVL, and AVF lie in the frontal plane of the body. The frontal plane consists of left-right and superior-inferior axes. The frontal plane reference figure demonstrates the bipolar and unipolar leads and their respective axes in degrees.

The frontal plane lead best representing left-right vectors is:

LEAD I	page 39
LEAD II	page 44
LEAD III	page 46



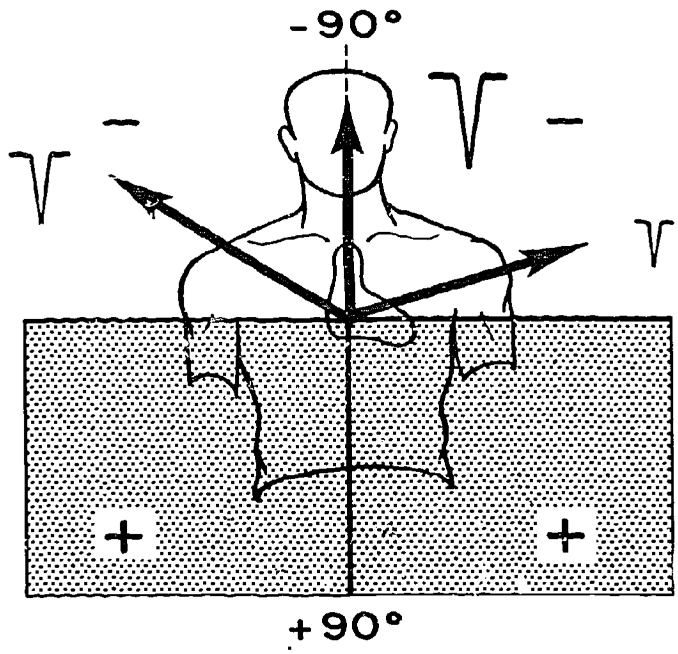


FRONTAL PLANE

From Page 30

Your answer, S WAVE, is incorrect.

An S wave or negative deflection indicates forces moving away from the positive electrode. The positive electrode of lead AVF is located inferior at +90°. An S wave, therefore, must indicate forces *moving superior* away from the positive electrode of lead AVF. A vector lying inferior between 0 and 180° lies within the positive field of lead AVF and, hence, cannot produce a negative deflection.



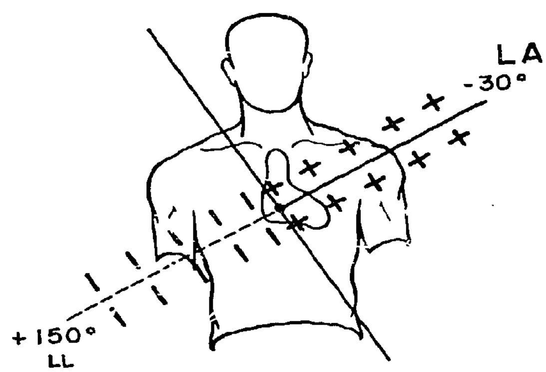
LEAD AVF

Return to page 30 and choose the correct answer.

From Page 38

Your answer, RIGHT AND INFERIOR AT +150°, is incorrect.

The axis of any lead may be divided at its center into a positive and a negative portion. The positive portion of this lead axis is adjacent to the positive electrode. If the positive half of the lead AVL axis were located right and inferior at +150°, the positive electrode of lead AVL would be located *incorrectly* on the right leg.



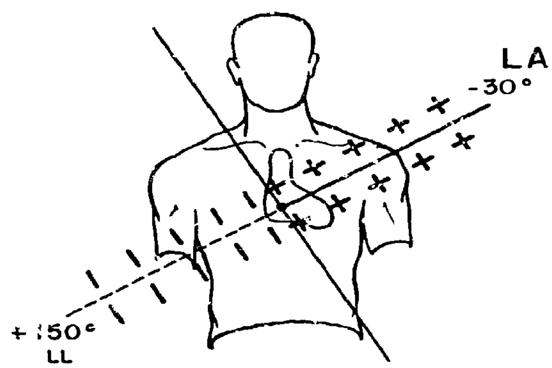
LEAD AVL

Return to page 38 and choose the correct answer.

From Page 38

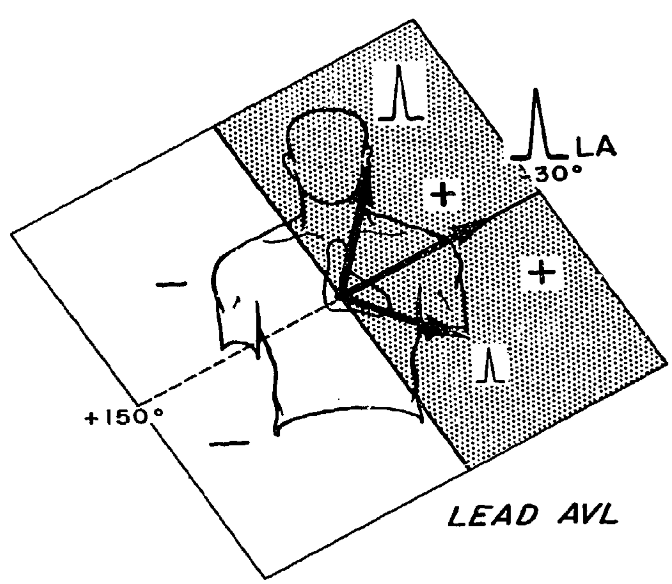
Your answer, LEFT AND SUPERIOR AT −30°, is correct.

The axis of any lead may be divided at its center into a positive and a negative portion. The positive portion of the lead axis is adjacent to the positive electrode; the negative portion is on the opposite side. Since the positive electrode of lead AVL is located on the left arm and its effective spatial location is the left shoulder, the positive portion of the lead AVL axis must be *left and superior* at −30°.



LEAD AVL

The perpendicular line through the center of the lead AVL axis also divides the body into a positive and a negative field. A vector lying in the positive field must be moving toward the positive electrode of lead AVL and, hence, must produce an upright deflection in this lead. A vector located in the negative field gives rise to a negative deflection in lead AVL.



LEAD AVL

Continue reading on page 37.

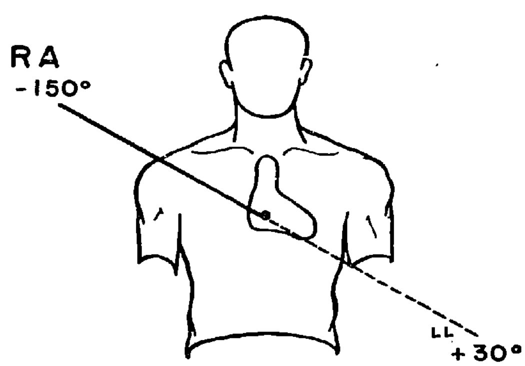
From Page 36

16

The positive electrode of lead AVR is located on the right arm; its effective spatial location is the right shoulder. The negative electrode is a central terminal whose effective location is 180° opposite the positive electrode.

The positive portion of the lead AVR axis is located:

RIGHT AND SUPERIOR AT −150°	page 32
LEFT AND INFERIOR AT +30°	page 27



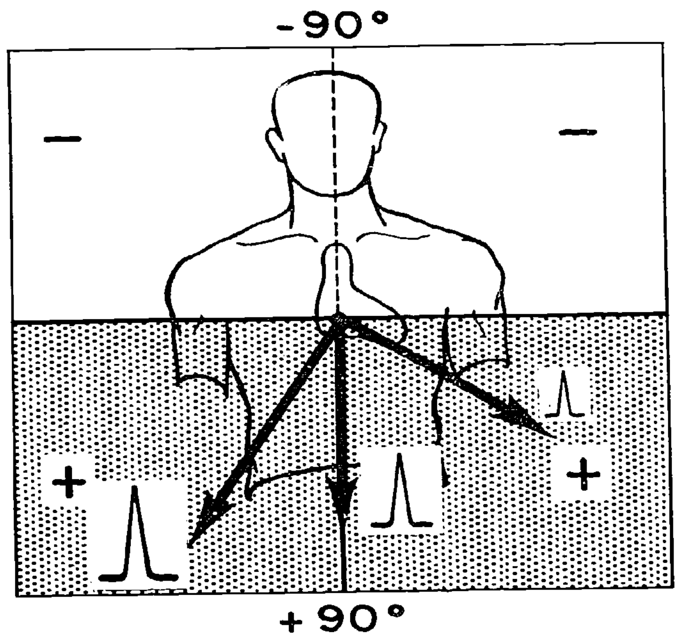
LEAD AVR

38

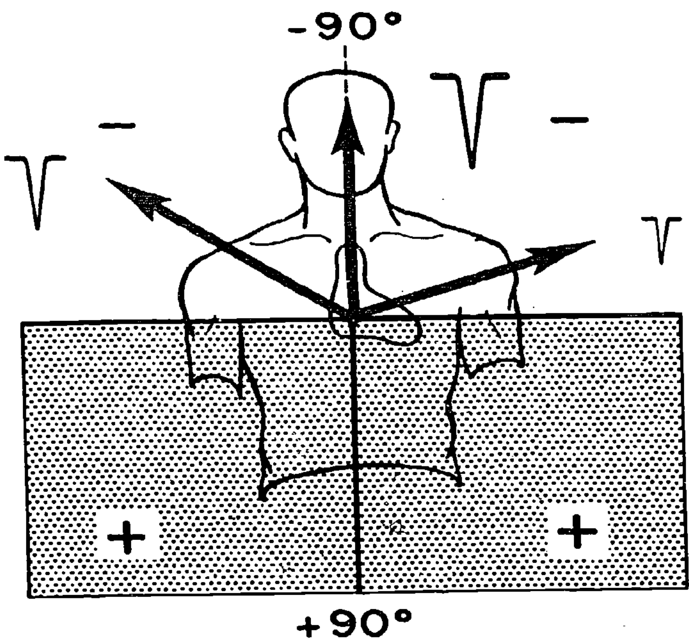
From Page 30

Your answer, R WAVE, is correct.

An R wave or upright deflection must indicate forces moving toward the positive electrode. The positive electrode of lead AVF is located at +90°. Therefore, a vector directed inferior between 0 and 180° lies in the positive field of lead AVF and must give rise to an R wave.



LEAD AVF



LEAD AVF

A QRS vector lying superior is moving away from the positive electrode and lies in the negative field of lead AVF and must give rise to a negative deflection in this lead.

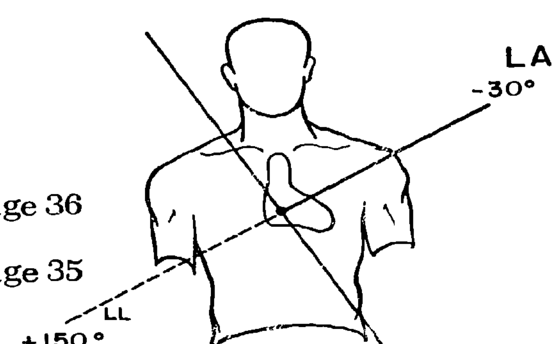
15

The positive electrode of lead AVL is on the left arm. The effective spatial location of this electrode is the left shoulder. The negative electrode is a central terminal whose effective location is 180° opposite the positive electrode.

The positive portion of the lead AVL axis is located:

LEFT AND SUPERIOR AT –30° page 36

RIGHT AND INFERIOR AT +150° page 35

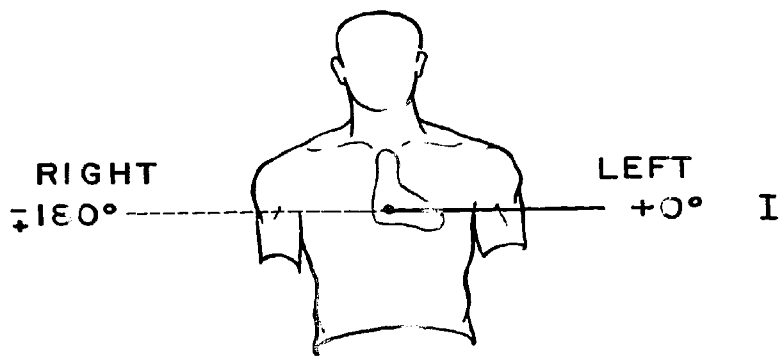


LEAD AVL

From Page 33

Your answer, LEAD I, is correct.

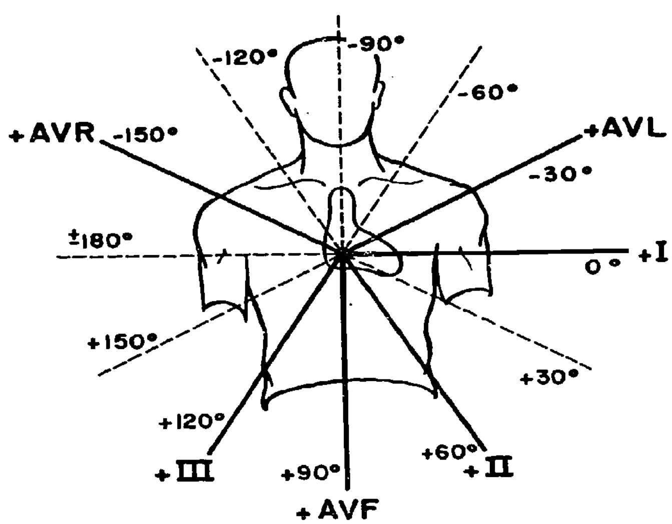
Lead I is oriented along the 0-180° axis and represents a left-right lead without superior or inferior tilt. *Lead I,* for spatial analysis, is the *best left-right* lead in the frontal plane.



18

The frontal plane lead best representing superior-inferior vectors is:

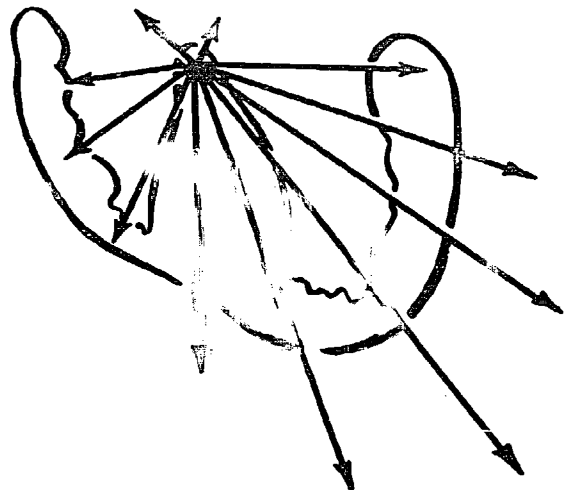
LEAD AVF	page 42
LEAD AVL	page 45
LEAD AVR	page 48



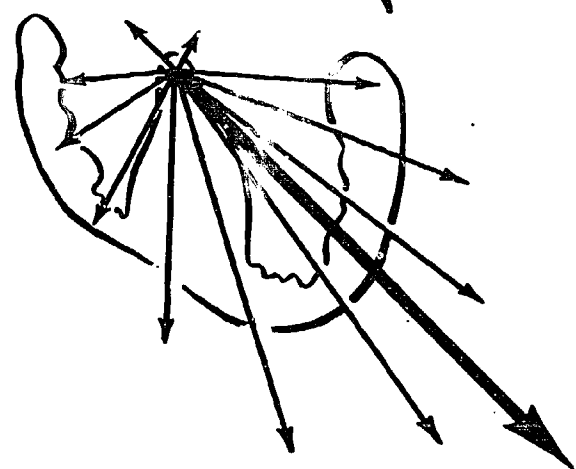
FRONTAL PLANE

Section II Mean Frontal QRS Vector

From Page 43

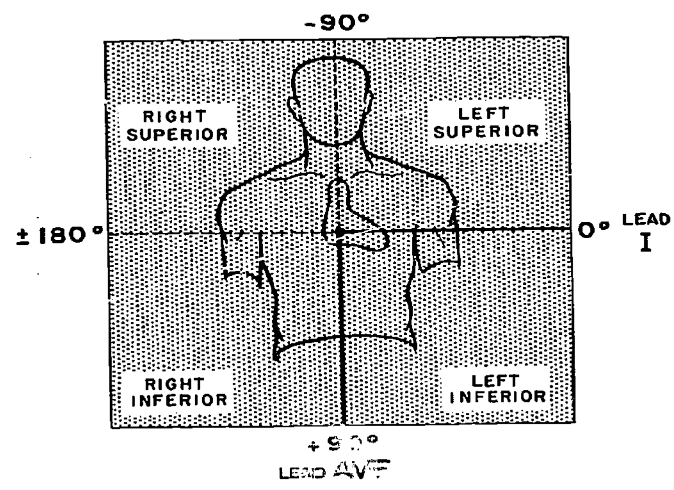


Each QRS complex in the electrocardiogram represents activation of the ventricles. During activation of the ventricles, an infinite number of QRS vectors are produced. These instantaneous QRS vectors are conducted to all portions of the body and represented in all leads.



All instantaneous QRS vectors produced during one ventricular activation may be added, resulting in *single QRS vector* having a *specific direction in space*. This single vector is called the *mean QRS vector;* the direction of the mean QRS vector is important in the diagnosis of heart disease.

In the frontal plane, the mean QRS vector of any electrocardiogram may be located by the *Quadrant and Perpendicular Rules of Spatial Analysis*. The *Quadrant Rule* localizes the mean QRS vector to one of the four frontal plane quadrants. This localization may be accomplished by utilizing the two leads best representing left-right and superior-inferior axes of the body, leads I and AVF, respectively.



FRONTAL PLANE

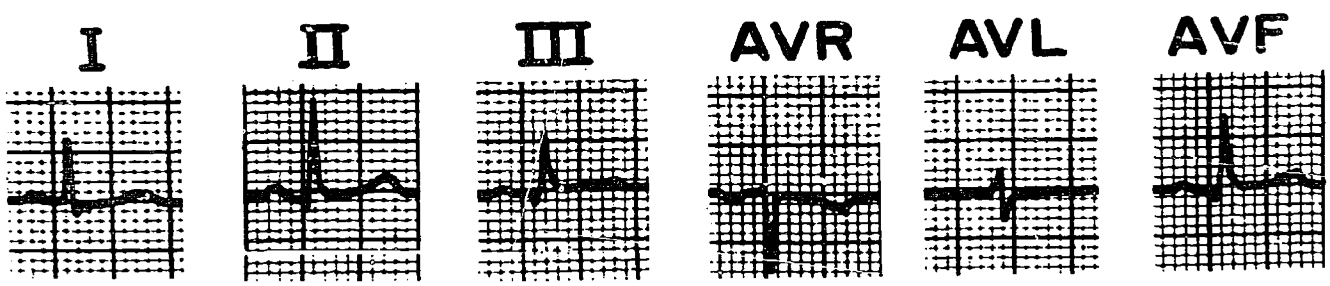
Please continue reading on page 41

From Page 40

19

The mean frontal QRS vector of any electrocardiogram may be determined by the *Quadrant Rule of Spatial Analysis*.

Frontal plane leads from an electrocardiogram are presented below.



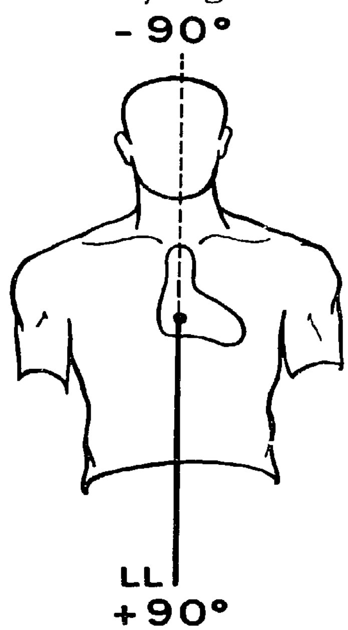
The predominant upright deflection, the R wave, in lead I of this tracing indicates the mean QRS vector along the left-right axis is:

LEFT	page 47
RIGHT	page 51

From Page 39

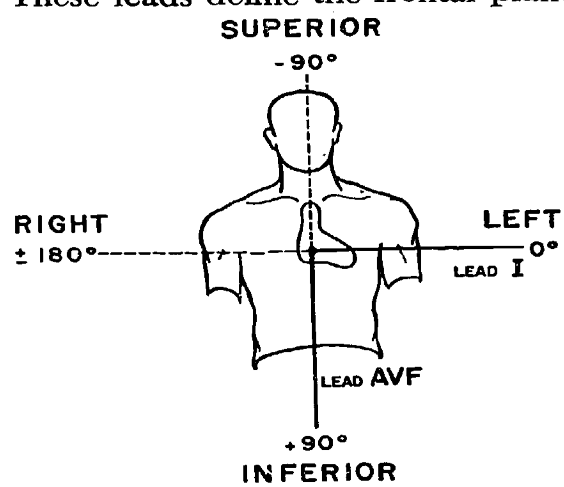
Your answer, LEAD AVF, is correct.

The positive electrode of lead AVF is located on the left leg; its effective spatial location is the symphysis pubis. The positive portion of the lead AVF axis is inferior at +90°. Lead AVF, therefore, is a *superior-inferior lead without a left-right tilt.*



LEAD AVF

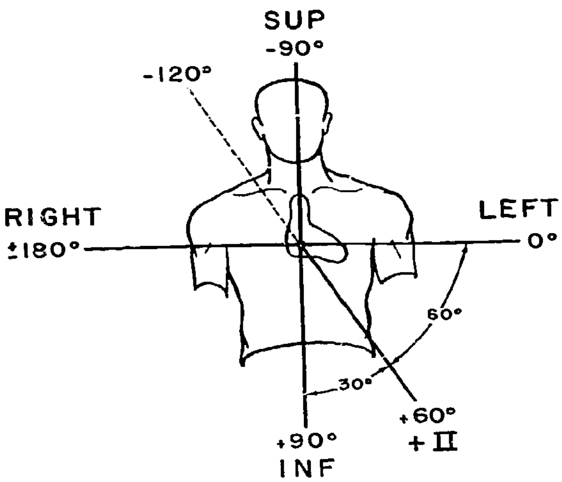
Leads I and AVF for Spatial Analysis are the best frontal plane leads for determining vectors along the left-right and superior-inferior axes of the body. These leads define the frontal plane.

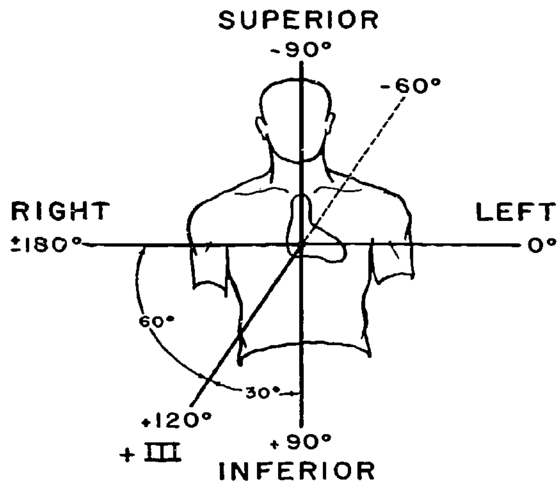


Continue reading on page 43.

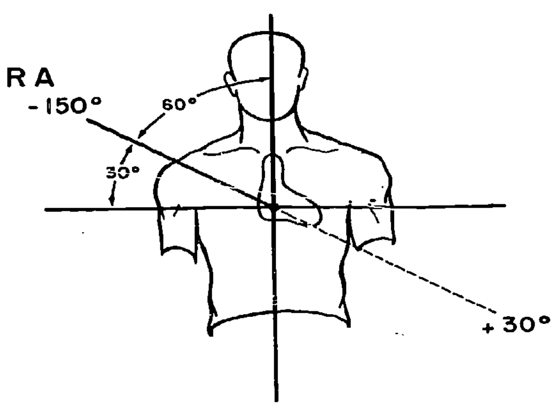
From Page 42

Leads II an˙ ıII are primarily superior-inferior leads with a left-right tilt.

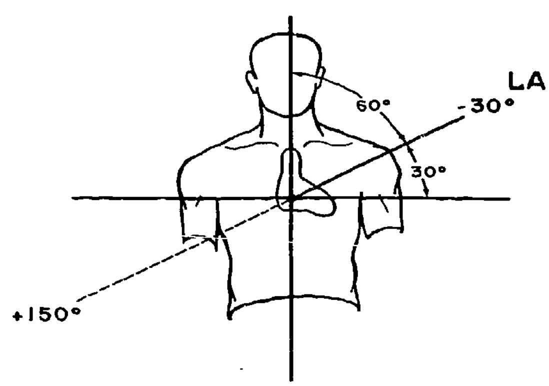




Leads AVR and AVL are primarily left-right leads with a superior-inferior tilt.



LEAD AVR



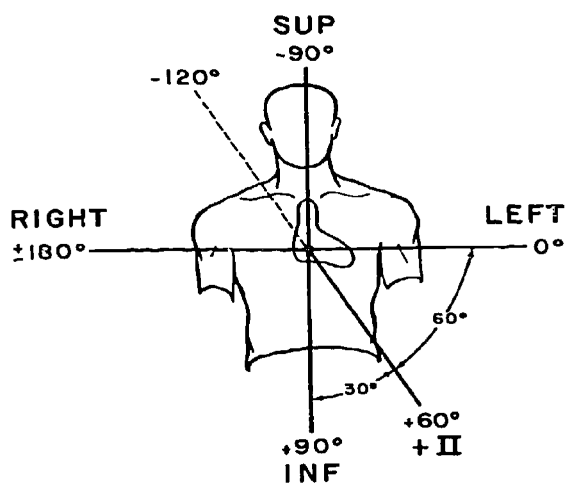
LEAD AVL

Please continue reading on page 40.

From Page 33

Your answer, LEAD II, is incorrect.

The positive portion of the lead II axis is located at +60° and the negative portion at −120°. Lead II is primarily a superior-inferior lead with a left-right tilt and is not the best left-right lead.

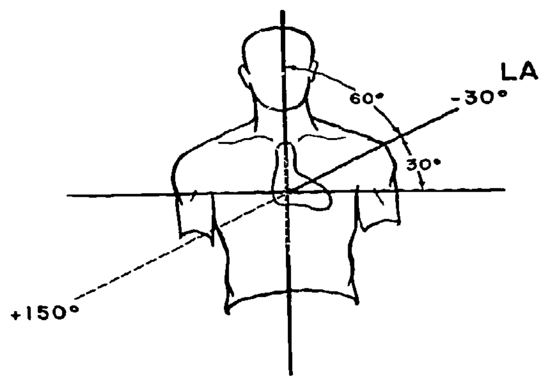


Return to page 33 and choose the correct answer.

From Page 39

Your answer, LEAD AVL, is incorrect.

The positive electrode of lead AVL is located on the left arm; its effective spatial location is the left shoulder. The positive portion of the lead AVL axis is left and superior at $-30°$. The axis of lead AVL is tilted 60° from the vertical and 30° from the left-right axis. Lead AVL, therefore, is primarily a left-right lead with a superior-inferior tilt and is not the best superior-inferior lead.



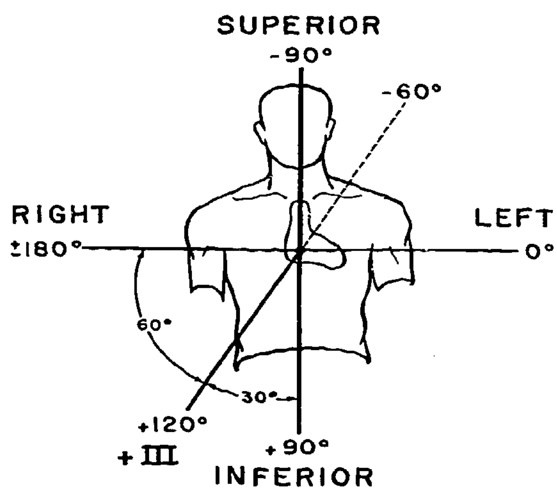
LEAD AVL

Return to page 39 and choose the correct answer.

From Page 33

Your answer, LEAD III, is incorrect.

The positive portion of the lead III axis is located right and inferior at $+120°$; the negative portion left and superior at $-60°$. Lead III is primarily a superior-inferior lead with a left-right tilt and is not the best left-right lead.

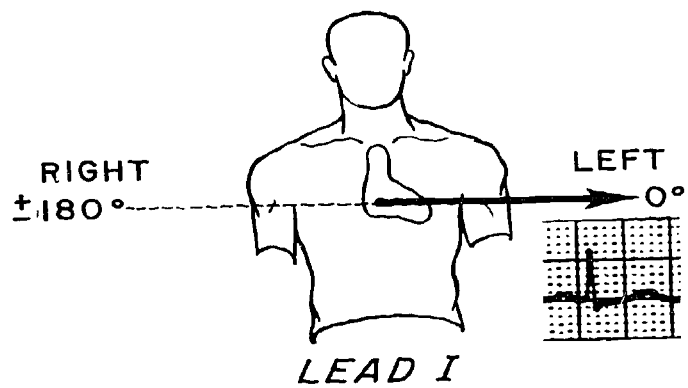


Return to page 33 and choose the correct answer.

From Page 41

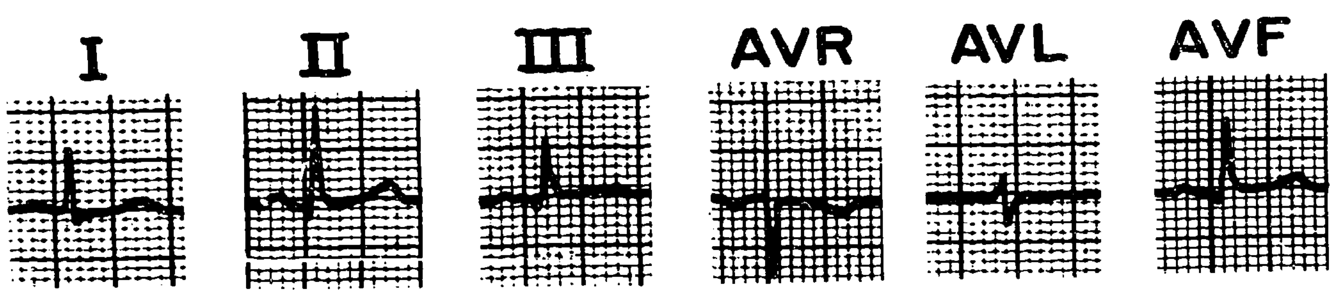
Your answer, LEFT, is correct.

Lead I displays a large R and a small S wave; the predominant deflection is positive. An upright deflection or R wave in lead I indicates forces are moving toward the positive electrode of that lead. Since the positive electrode of lead I is located on the left arm, the predominant R wave indicates QRS forces are left.



20

The mean frontal QRS vector may be localized to a quadrant by the Quadrant Rule of Spatial Analysis. The Quadrant Rule localizes the net QRS forces along the left-right and superior-inferior axes.



The predominant R wave in lead AVF, the superior-inferior lead, indicates the net QRS forces along the superior-inferior axis are:

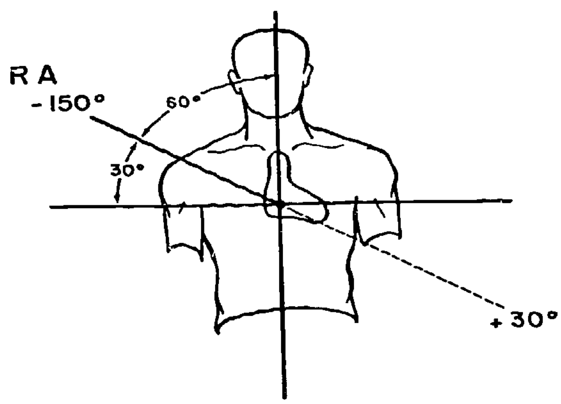
SUPERIOR page 52

INFERIOR page 50

From Page 39

Your answer, LEAD AVR, is incorrect.

The positive electrode of lead AVR is located on the right arm; its effective spatial location is the right shoulder. The positive portion of the lead AVR axis is right and superior at $-150°$. The axis of lead AVR is tilted $60°$ from the vertical and $30°$ from the left-right axis. Lead AVR is primarily a left-right lead with a superior-inferior tilt and, therefore, is not the best superior-inferior lead.



LEAD AVR

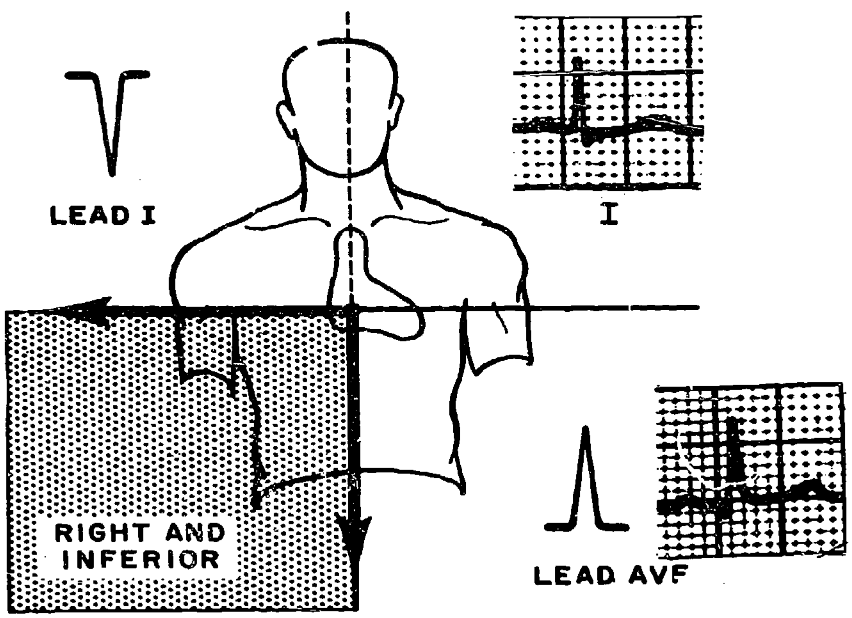
Return to page 39 and choose the correct answer.

From Page 50

Your answer, RIGHT AND INFERIOR, is incorrect.

The R wave in lead AVF indicates the mean QRS vector is inferior; this portion of your answer is correct.

Rightward QRS forces demand a negative deflection in lead I. The tracing, however, does not present a predominant negative QRS deflection in lead I.

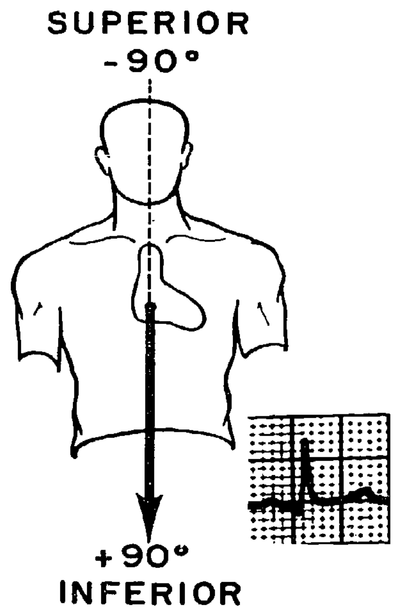


Return to page 50 and choose the correct answer.

From Page 47

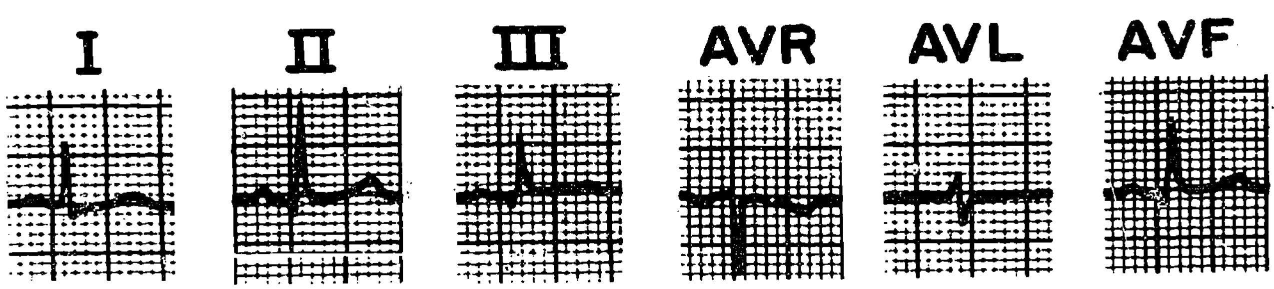
Your answer, INFERIOR, is correct.

The predominant R wave in lead AVF indicates QRS forces are moving toward the positive electrode of this lead. Since the positive electrode of lead AVF is located on the left leg, and the effective spatial location is the symphysis pubis, QRS forces must be moving inferior.



21 *LEAD AVF*

The mean frontal QRS vector may be localized to a quadrant by combining the net QRS vectors determined from the left-right and superior-inferior leads.



According to the Quadrant Rule, the mean frontal QRS vector in this tracing is:

RIGHT AND INFERIOR page 49

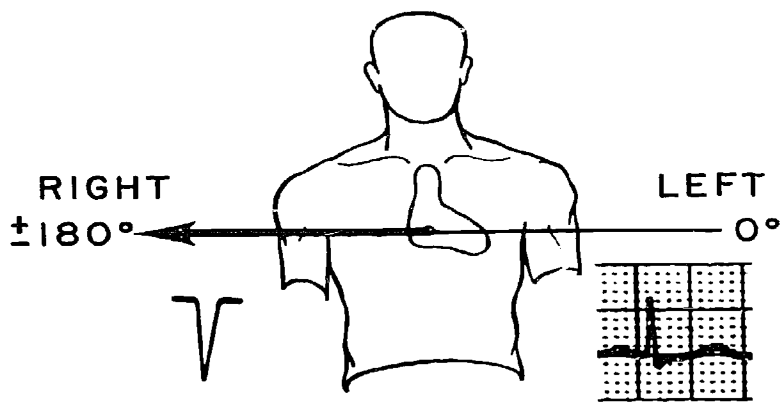
LEFT AND SUPERIOR page 53

LEFT AND INFERIOR page 54

From Page 41

Your answer, RIGHT, is incorrect.

A QRS vector moving right indicates forces are moving toward the negative electrode of lead I; forces moving toward the negative electrode must give rise to a predominant negative deflection. Lead I in this electrocardiogram does not display a predominant negative deflection.



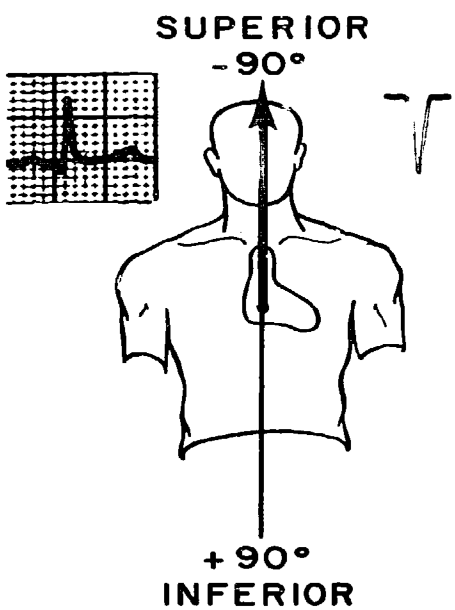
LEAD I

Return to page 41 and choose the correct answer.

From Page 47

Your answer, SUPERIOR, is incorrect.

A superior QRS vector indicates QRS forces are moving away from the positive electrode of lead AVF. Since the positive electrode of lead AVF is located on the left leg, forces moving *away* from the positive electrode would give rise to a predominant negative deflection.



LEAD AVF

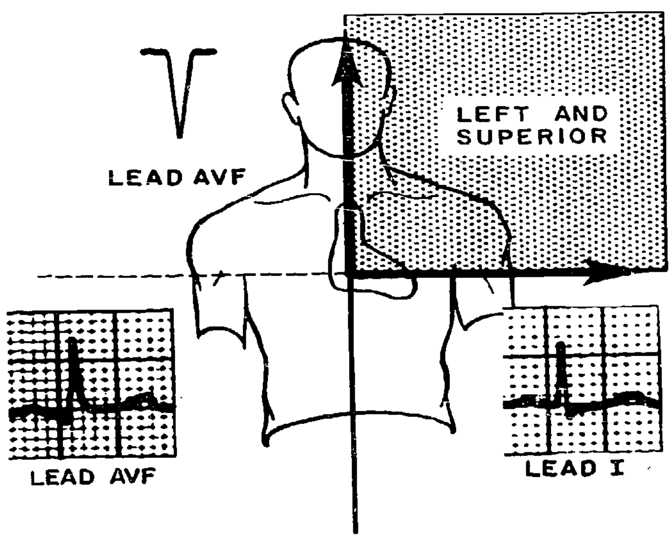
Return to page 47 and choose the correct answer.

From Page 50

Your answer, LEFT AND SUPERIOR, is incorrect.

The upright deflection, the R wave in lead I, indicates QRS forces are left; your answer is partially correct.

Superior forces would be directed away from the positive electrode in lead AVF; forces moving away from the positive electrode of lead AVF must give rise to a predominant negative deflection in this lead. This tracing, however, does not display a predominant negative deflection in lead AVF.

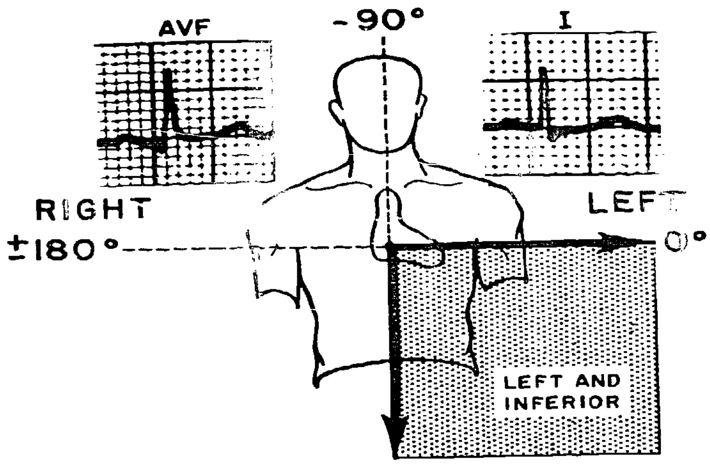


Return to page 50 and choose the correct answer.

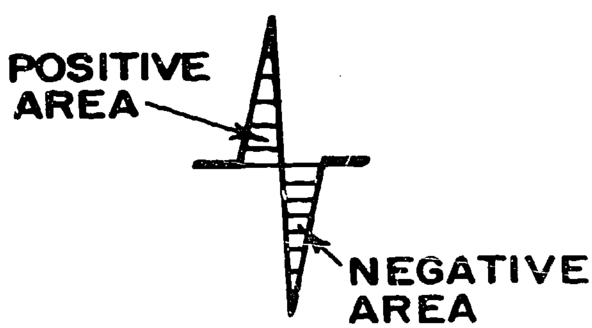
From Page 50

Your answer, LEFT AND INFERIOR, is correct.

Net QRS forces along the left-right axis were determined to be *left* (upright deflection in lead I); net QRS forces along the superior-inferior axis were *inferior* (large R wave in lead AVF). Combining these net left-right and superior-inferior forces localizes the mean frontal QRS vector to the *left and inferior quadrant*. The Quadrant Rule is the first step in determining the mean frontal QRS vector.



An upright deflection in any lead indicates QRS forces are moving toward the positive electrode of that lead; a negative deflection indicates QRS forces are moving away from the positive electrode. An *equiphasic complex* is one in which the area under the upright deflection and the area under the negative deflection are *equal*. When added, these positive and negative areas are zero, indicating *net QRS* forces must be moving *perpendicular to the axis of this lead*.



EQUIPHASIC COMPLEX

Continue reading on page 55.

From Page 54

22

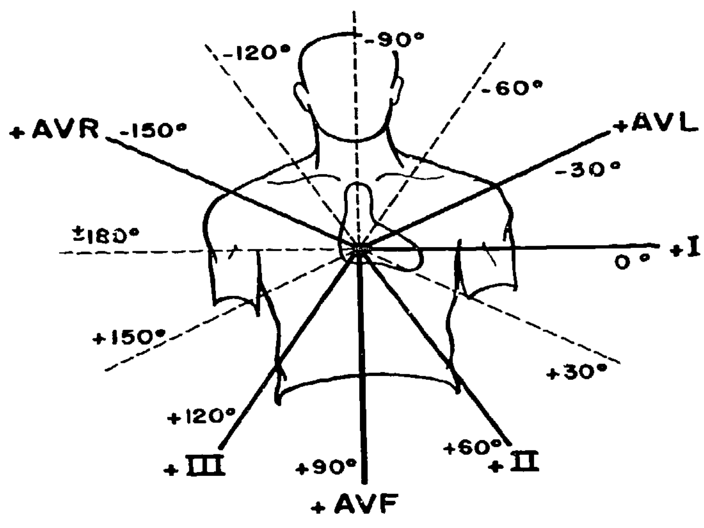
The *Perpendicular Rule of Spatial Analysis* is used to localize the mean QRS vector in degrees. The Perpendicular Rule states the mean QRS vector lies perpendicular to the axis of the lead with the equiphasic complex and in the preselected quadrant. In this tracing the QRS complex in lead AVL is equiphasic (net positive and negative area is zero). By the *Quadrant Rule* the mean QRS vector has been localized to the left and inferior quadrant.

The mean frontal QRS vector in this tracing is left and inferior at:

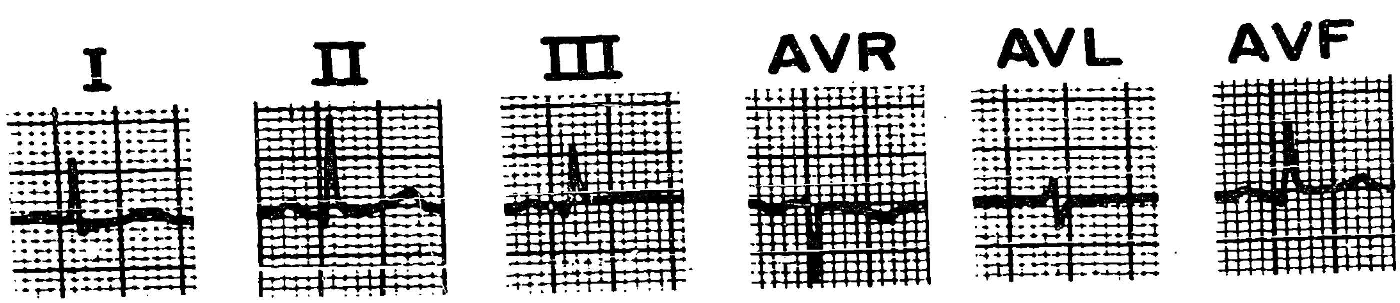
+30° page 57

+60° page 62

+90° page 60



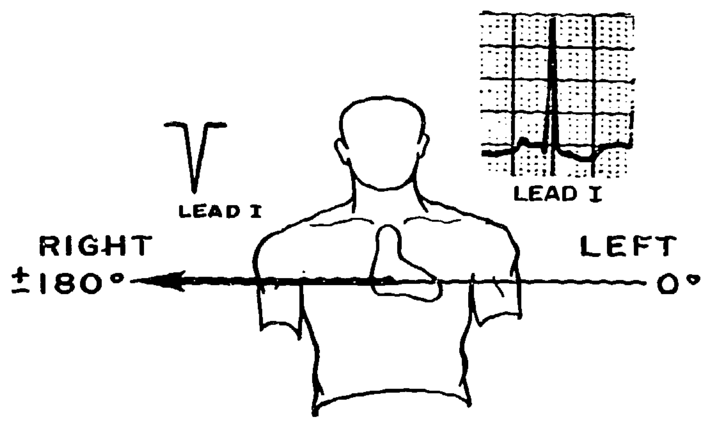
FRONTAL PLANE



From Page 62

Your answer, RIGHT, is incorrect.

A rightward QRS vector results from QRS forces moving away from the positive electrode of lead I. QRS forces moving away from the positive electrode of lead I must give rise to a predominant negative deflection in this lead. The QRS complex in lead I in this tracing is not a predominant negative deflection.



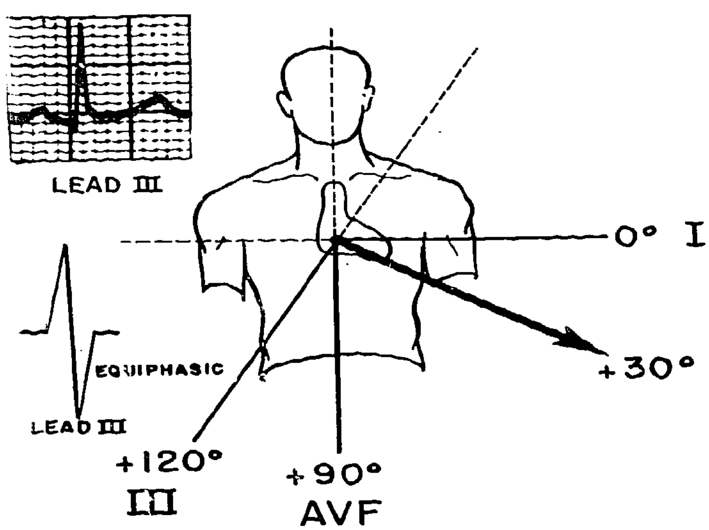
LEAD I

Return to page 62 and choose the correct answer.

From Page

Your answer, +30°, is incorrect.

The *Perpendicular Rule of Spatial Analysis* states the mean QRS vector is perpendicular to the axis of the lead with the equiphasic complex. A mean QRS vector *left and inferior at +30°* lies perpendicular to the axis of lead III. Lead III in this tracing, however, does not display an equiphasic QRS complex.



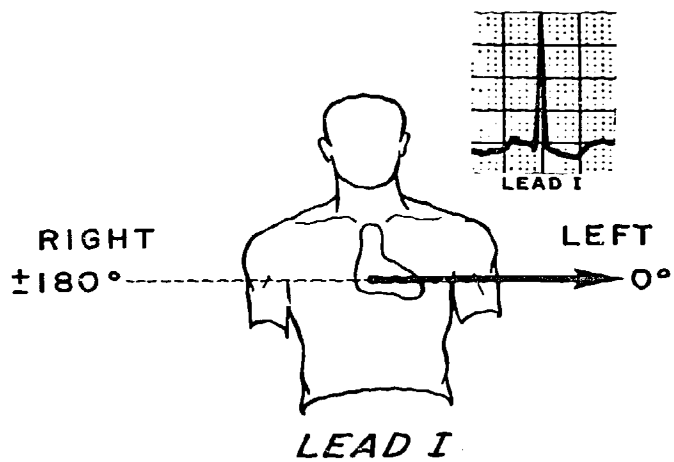
Return to page 55 and choose the correct answer.

58

From Page 62

Your answer, LEFT, is correct.

The predominant upright deflection in lead I indicates QRS forces are moving toward the positive electrode of this lead. Since the positive electrode of lead I is located on the left arm, QRS forces must be *left*.

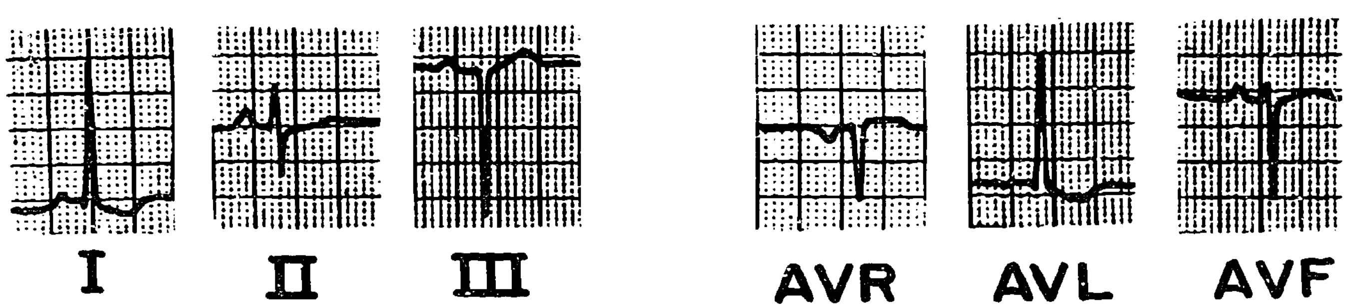


24

The QRS complex in lead AVF indicates net QRS forces along the superior-inferior axis are:

INFERIOR page 61

SUPERIOR page 64



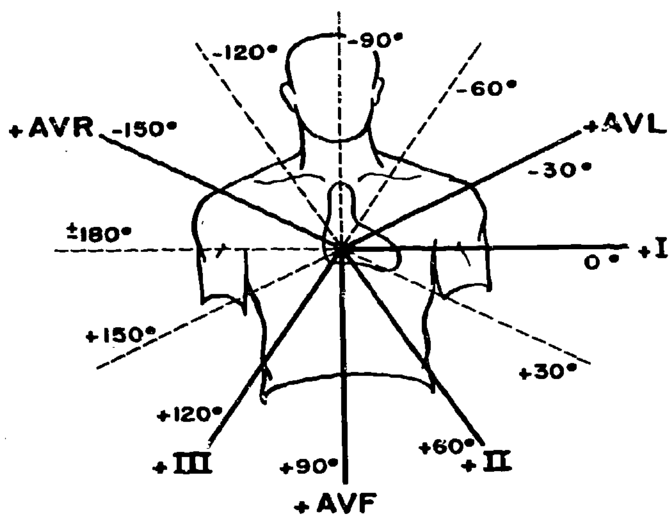
From Page 63

26

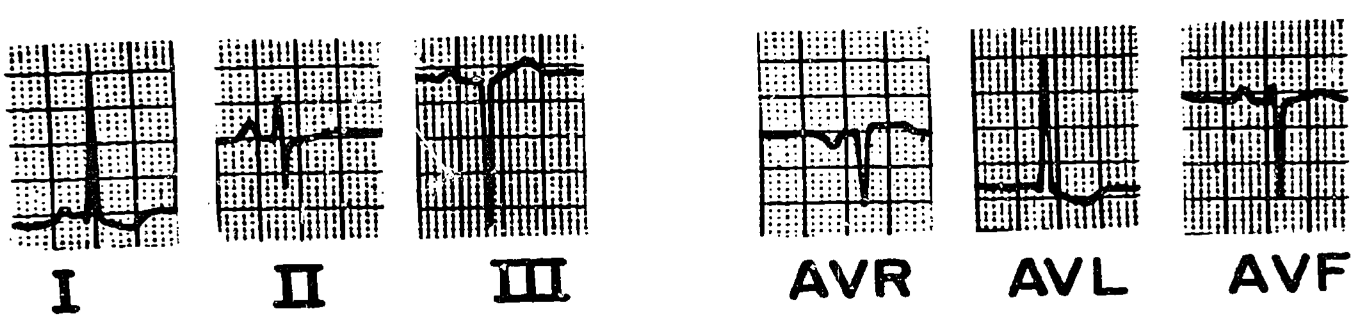
The mean QRS vector may be localized in degrees by the *Perpendicular Rule of Spatial Analysis:*

The mean frontal QRS vector in this tracing is located left and superior at:

0°	page 66
–30°	page 68
–60°	page 65



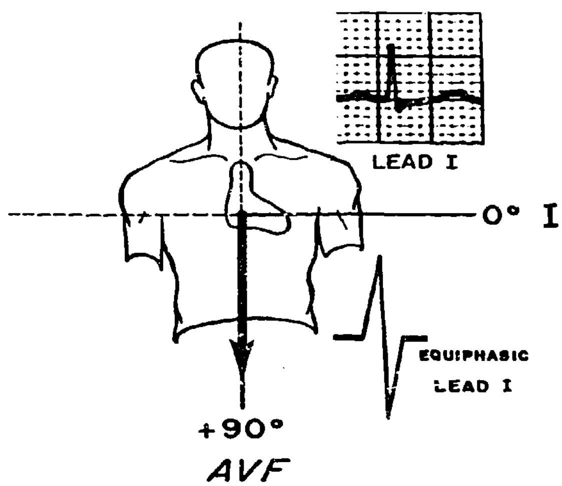
FRONTAL PLANE



From Page 55

Your answer, +90°, is incorrect.

The *Perpendicular Rule of Spatial Analysis* states the mean QRS vector is perpendicular to the axis of the lead with the equiphasic complex. A mean QRS vector *inferior at +90°* is perpendicular to the axis of lead I. Lead I in this tracing, however, does not display an equiphasic complex.

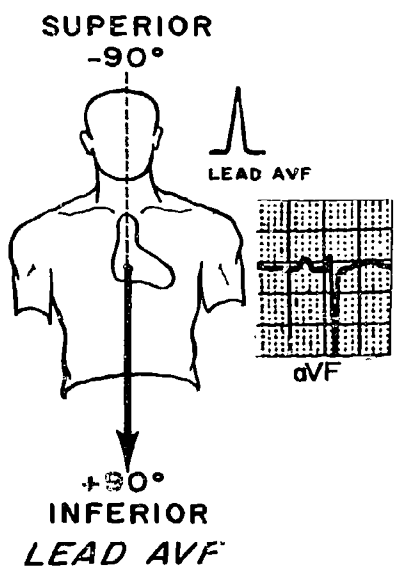


Return to page 55 and choose the correct answer.

From Page 58

Your answer, INFERIOR, is incorrect.

Inferior QRS vectors must be moving toward the positive electrode of lead AVF. QRS forces moving toward the positive electrode must give rise to a predominantly upright QRS complex in this lead. This tracing, however, does not present a predominant upright deflection in lead AVF.

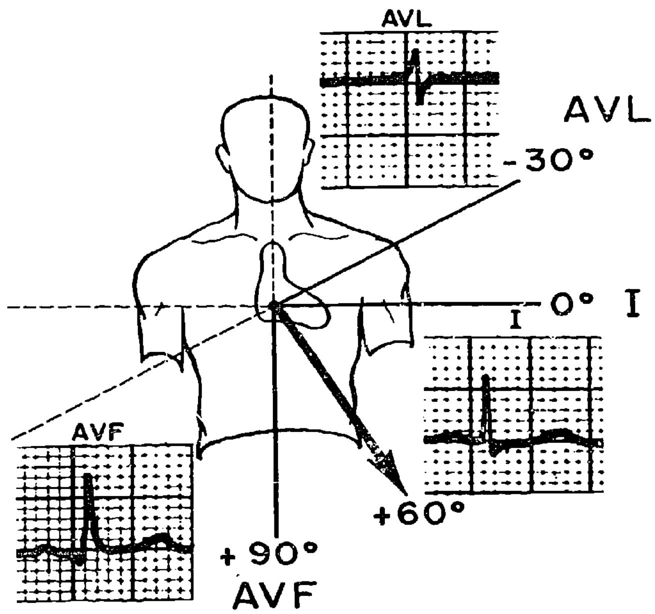


Return to page 58 and choose the correct answer.

From Page 55

Your answer, +60°, is correct.

The *Perpendicular Rule of Spatial Analysis* states the mean QRS vector is perpendicular to the axis of the lead with the equiphasic complex and in the preselected quadrant. In this tracing the equiphasic complex is in lead AVL. The perpendicular to the axis of lead AVL is +60° or −120°. Since the Quadrant Rule has preselected the left and inferior quadrant, the mean QRS vector must be left and inferior at +60°.



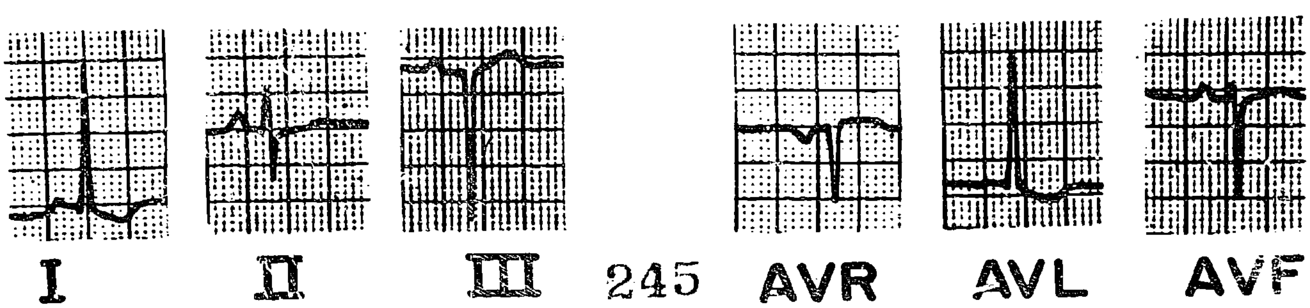
23

The mean frontal QRS vector may be localized in space by the *Quadrant and Perpendicular Rules of Spatial Analysis.*

Frontal plane leads of an electrocardiogram are presented below.

The R wave in lead I of this tracing indicates the mean QRS vector along the left-right axis is:

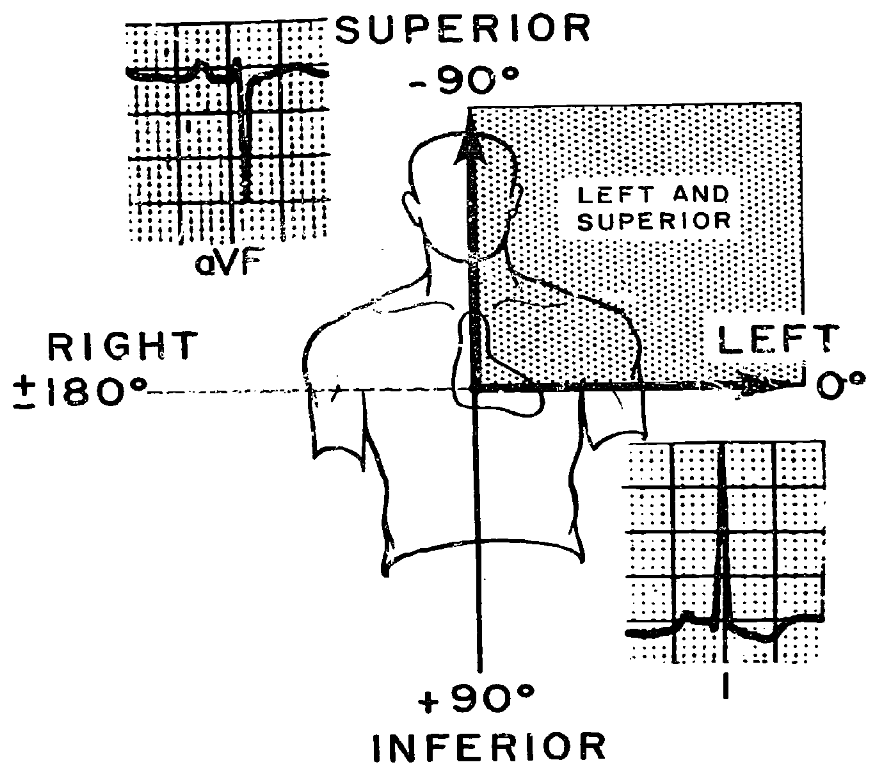
RIGHT	page 56
LEFT	page 58



From Page 64

Your answer, LEFT and SUPERIOR, is correct.

The upright deflection in lead I of this tracing indicates net QRS forces are left; the predominant negative deflection in lead AVF indicates net QRS forces are *superior*. This localizes the mean frontal QRS vector to the *left and superior quadrant*.

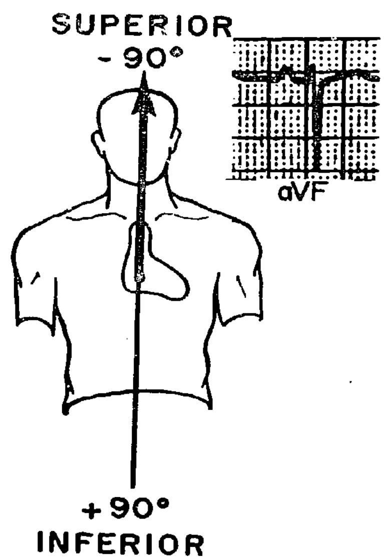


Continue reading on page 59.

From Page 58

Your answer, SUPERIOR, is correct.

Lead AVF in this tracing presents a small upright deflection followed by a much larger negative deflection; this results in a *net negative QRS complex*. A predominant negative deflection indicates net QRS forces are moving away from the positive electrode. Since the positive electrode of lead AVF is inferior, forces moving away from the positive electrode must be *superior*.



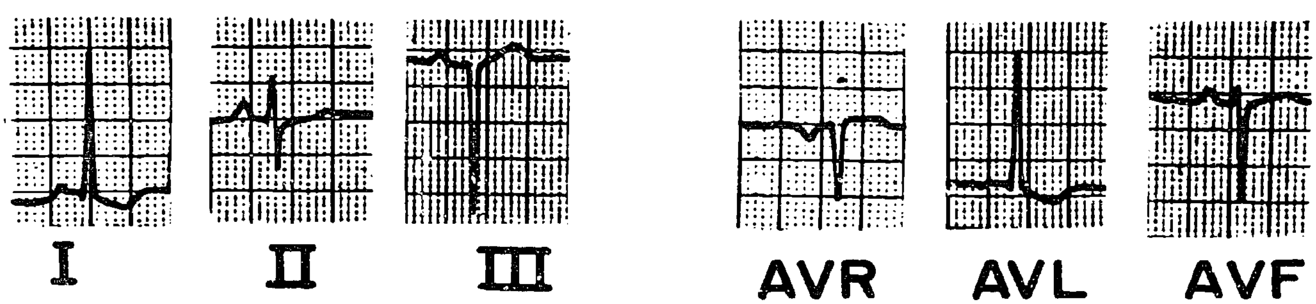
LEAD AVF

25

The mean frontal QRS vector in this tracing, according to the *Quadrant Rule of Spatial Analysis*, is:

LEFT AND SUPERIOR page 63

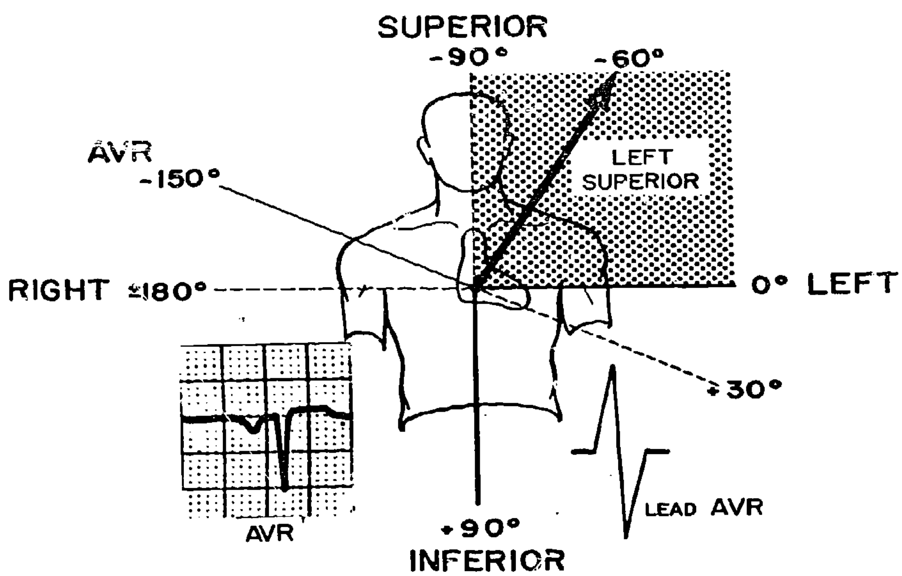
RIGHT AND INFERIOR page 67



From Page 59

Your answer, —60°, is incorrect.

The *Perpendicular Rule of Spatial Analysis* states the mean QRS vector is perpendicular to the axis of the lead with the equiphasic complex. A mean QRS vector at *—60°* would require an equiphasic complex in lead AVR. Lead AVR in this tracing, however, does not display an equiphasic QRS complex.

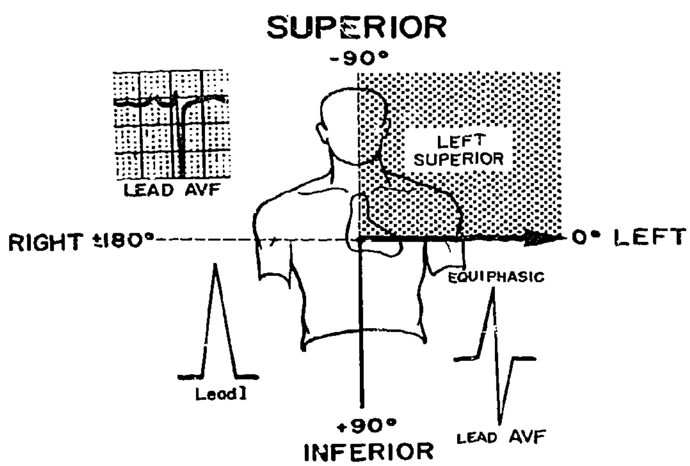


Return to page 59 and choose the correct answer.

From Page 59

Your answer, 0°, is incorrect.

The *Perpendicular Rule of Spatial Analysis* states the mean QRS vector is perpendicular to the axis of the lead with the equiphasic complex. A mean QRS vector *left at 0°* would require an equiphasic QRS complex in lead AVF. Lead AVF, however, does not display an equiphasic QRS complex in this tracing.

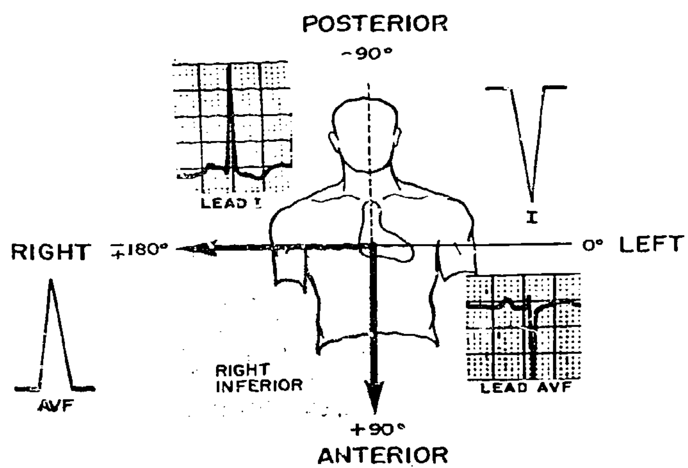


Return to page 59 and choose the correct answer.

From Page 64

Your answer, RIGHT AND INFERIOR, is incorrect.

Rightward QRS forces give rise to a predominant negative deflection in lead I; inferior forces give rise to a predominant upright deflection in lead AVF. This tracing, however, does not display a predominant negative deflection in lead I nor a predominant upright deflection in lead AVF.

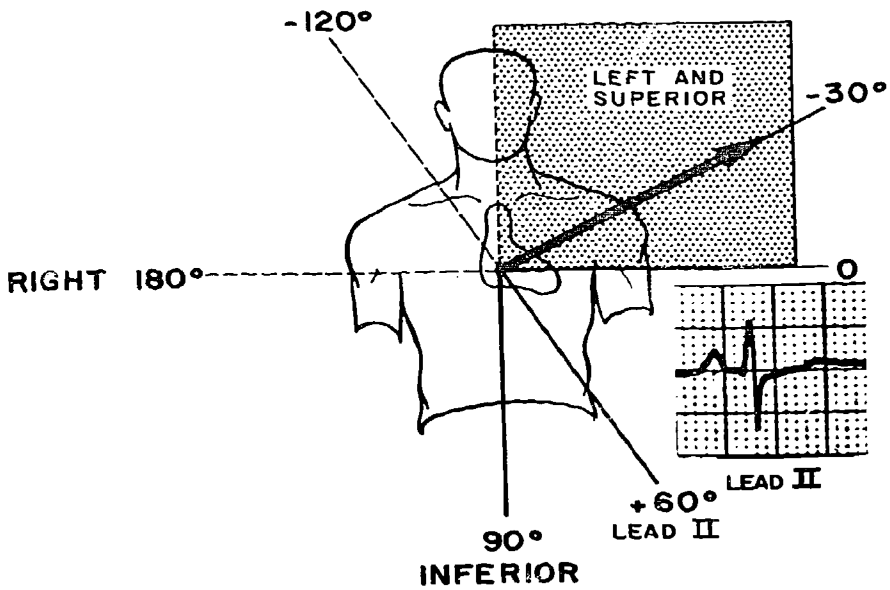


Return to page 64 and choose the correct answer.

From Page 59

Your answer, —30°, is correct.

The *Perpendicular Rule of Spatial Analysis* states the mean QRS vector is perpendicular to the axis of the lead with the equiphasic complex and in the preselected quadrant. Lead II displays an equiphasic QRS complex. The perpendicular to the axis of lead II in the preselected left and superior quadrant is —30°.



Continue reading on page 69.

SUMMARY

The Introduction to Spatial Analysis has emphasized the following points:

1. An upright deflection, an R wave, in any lead represents QRS forces moving toward the positive electrode of that lead.

2. The two principle axes of the frontal plane may be represented best by lead I for the left-right axis and lead AVF for the superior-inferior axis. An upright deflection, therefore, must represent leftward QRS forces in lead I and inferior QRS forces in lead AVF.

3. The mean frontal QRS vector may be localized with the *Quadrant Rule of Spatial Analysis* by combining the net QRS vectors from the left-right and superior-inferior leads.

4. The mean frontal QRS vector may be fixed more precisely in degrees with the *Perpendicular Rule of Spatial Analysis*. This rule states the mean QRS vector is perpendicular to the axis of the lead with the equiphasic QRS complex and in the preselected quadrant.

This is a convenient place to pause, if you wish.

To continue reading—please turn to page 71.

From Page 69

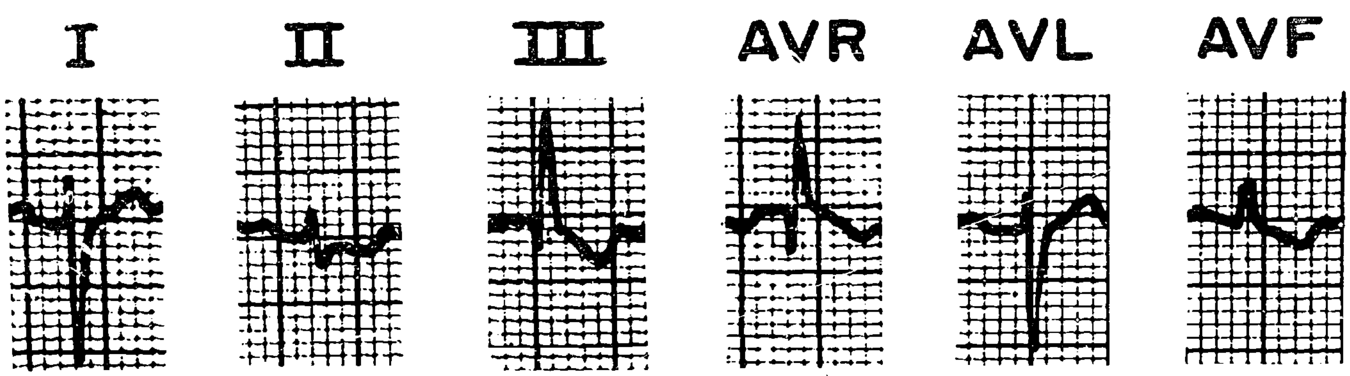
27

Frontal plane leads from an electrocardiogram are presented below. The mean QRS vector in the frontal plane of this tracing is localized:

RIGHT AND SUPERIOR page 73

RIGHT AND INFERIOR page 75

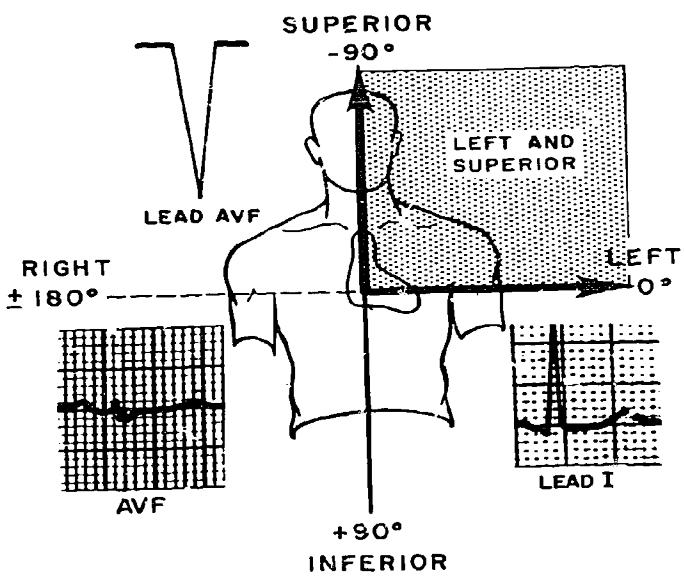
LEFT AND INFERIOR page 76



From Page 82

Your answer, LEFT AND SUPERIOR, is incorrect.

The predominant upright deflection in lead I indicates net QRS forces are left; your answer is partially correct. If the mean QRS vector were superior, however, there would be a predominant negative deflection in lead AVF. The QRS complex in lead AVF of this tracing is not predominantly negative.



If you selected this incorrect response because of a *careless* mistake *—Turn to page 82—and select the correct answer.*

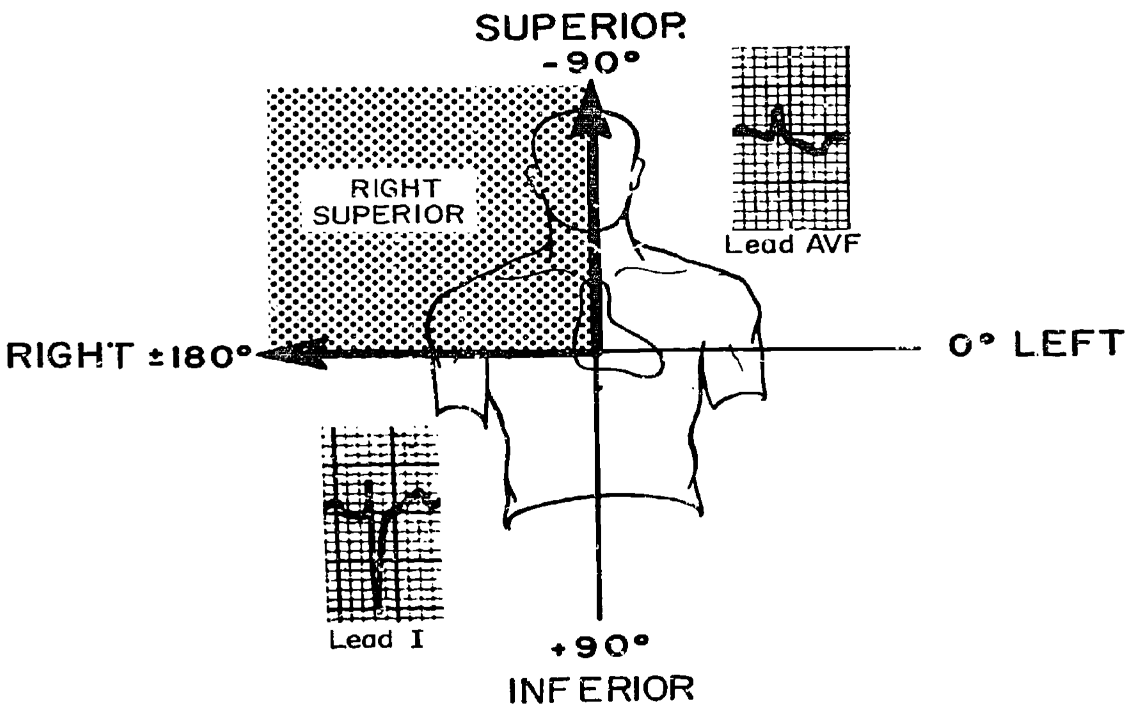
If you do not understand the *basic concept* of the Quadrant Rule *—Return to page 40—and repeat this material.*

From Page 71

Your answer, RIGHT AND SUPERIOR, is incorrect.

The predominant negative deflection in lead I indicates net QRS forces are right; this portion of your answer is correct.

If the mean QRS vector were superior, however, there would be a predominant negative deflection in lead AVF. Lead AVF in this tracing does not display a predominant negative deflection.



If you selected this incorrect response because of a *careless* mistake —*Return to page 71 and select the correct answer.*

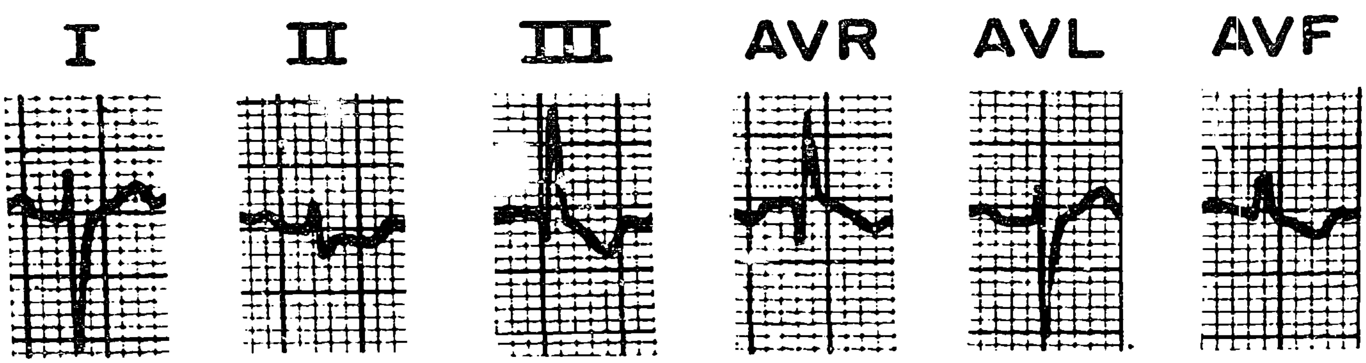
If you do not understant the *basic concept* of the Quadrant Rule, —*Return to page 40 and repeat this material.*

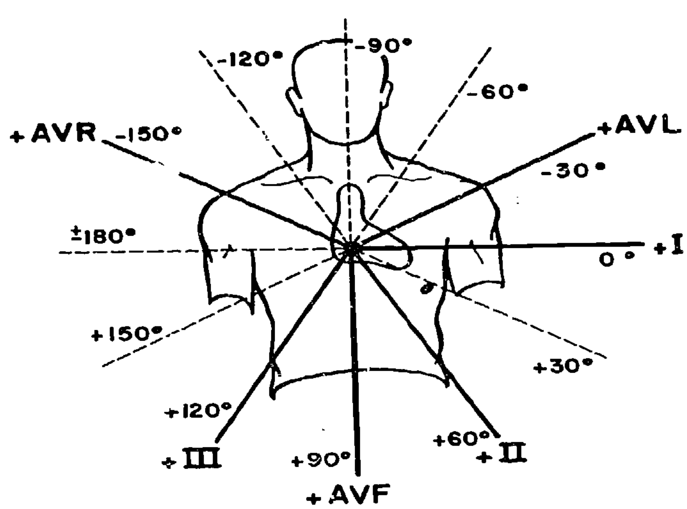
From Page 75

28

The mean frontal QRS vector in this same tracing is:

+120°	page 77
+150°	page 83
−30°	page 79



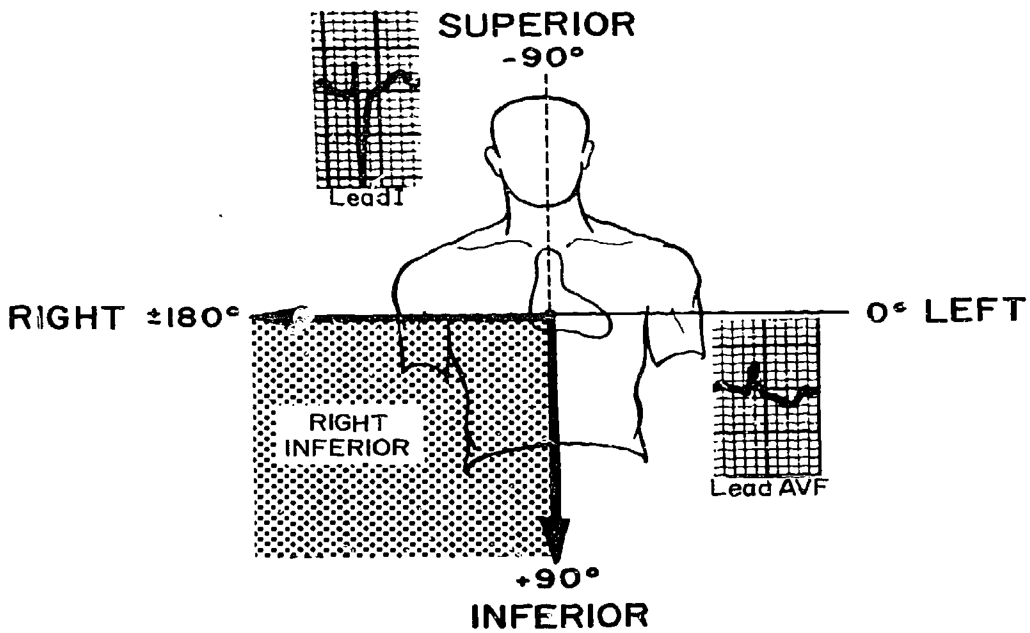


FRONTAL PLANE

From Page 71

Your answer, RIGHT AND INFERIOR, is correct.

The predominant negative deflection in lead I indicates net QRS forces are *right;* the predominant upright deflection in lead AVF indicates net QRS forces are *inferior*. The mean frontal QRS vector in this tracing, therefore, is localized *right and inferior*.



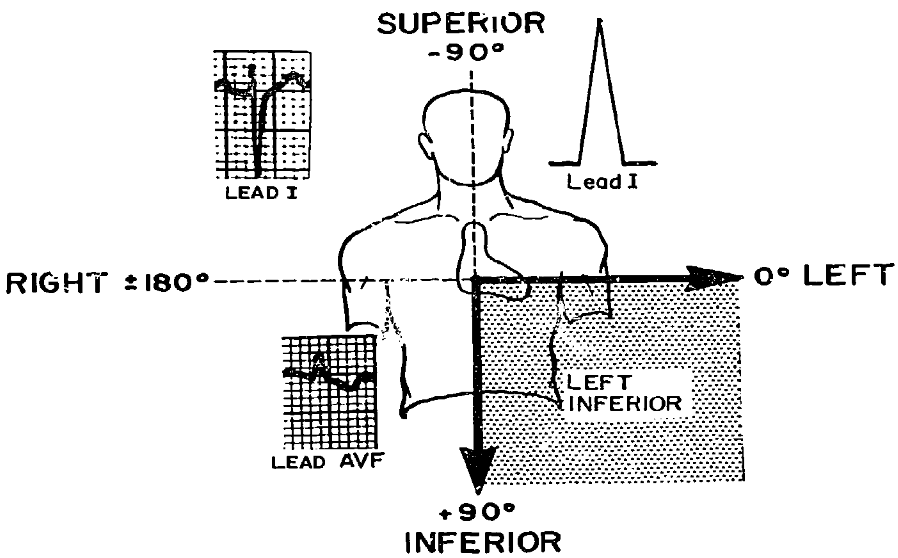
Continue reading on page 74.

From Page 71

Your answer, LEFT AND INFERIOR, is incorrect.

The predominant upright deflection in lead AVF indicates net QRS forces are inferior; this portion of your answer is correct.

If the mean QRS vector were left, however, there would be a predominant upright deflection or R wave in lead I. The predominant QRS deflection in lead I of this tracing is not upright.



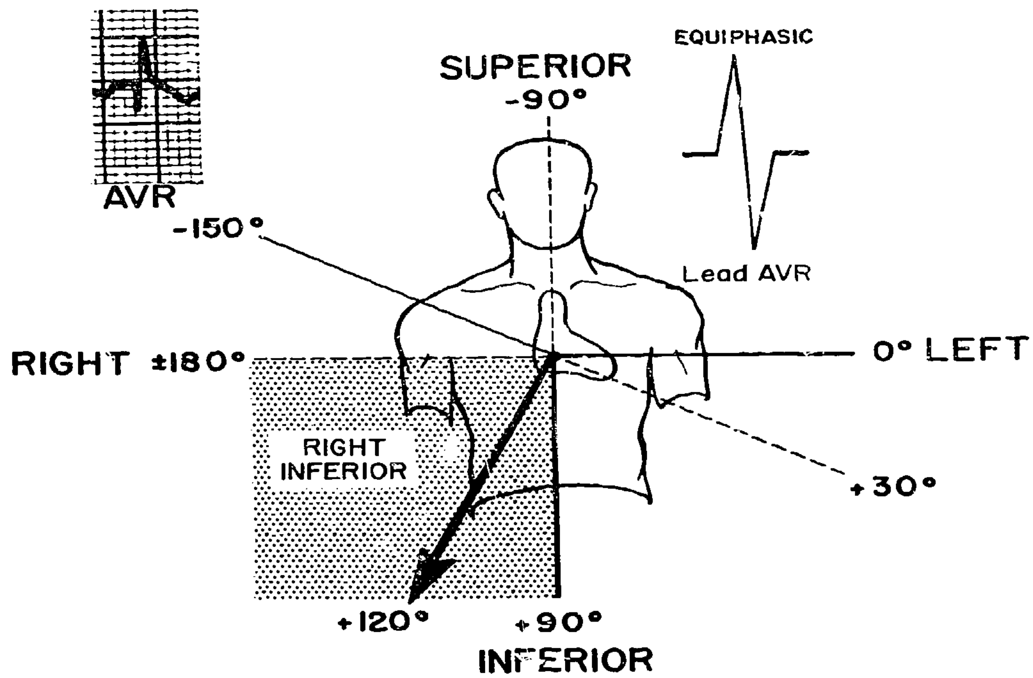
If you selected this incorrect response because of a *careless* mistake *Return to page 71 and select the correct answer.*

If you do not understand the *basic concept* of the Quadrant Rule, *—Return to page 40 and repeat this material.*

From Page 74

Your answer, $+120°$, is incorrect.

The mean QRS vector is perpendicular to the lead with the equiphasic QRS complex. A mean QRS vector at $+120°$ would require an equiphasic QRS complex in lead AVR. Lead AVR in this tracing, however, has a Q wave and a larger R wave; it is not the lead with the equiphasic complex.

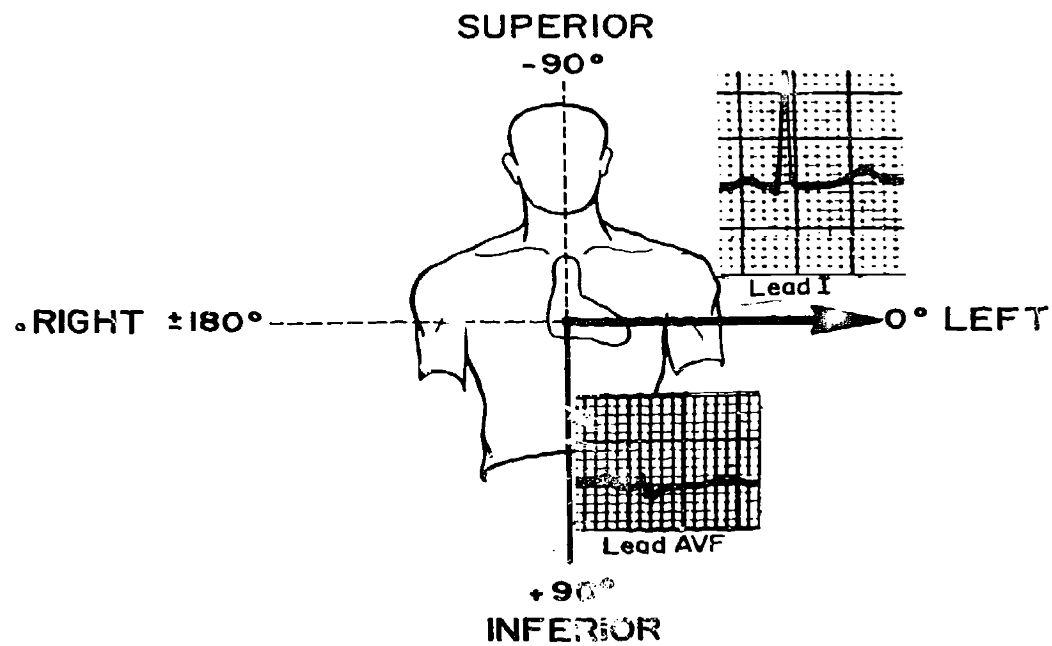


Return to page 74 and choose the correct answer.

From Page 82

Your answer, LEFT AND NEITHER SUPERIOR *NOR* INFERIOR, is correct.

The upright deflection in lead I of this tracing indicates net QRS forces are *left;* the equiphasic complex in lead AVF indicates net QRS f[illegible]s lie *perpendicular to the axis of lead AVF*. The mean frontal QRS vector, therefore is left at 0° and neither superior nor inferior.

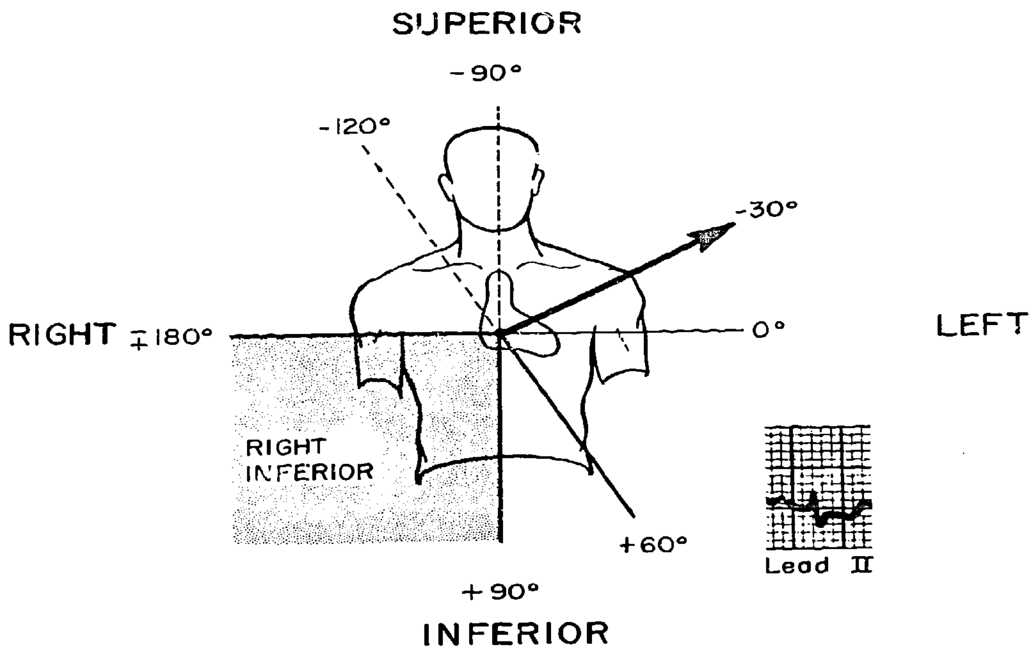


Continue reading on page 84.

From Page 74

Your answer, —30°, is incorrect.

The mean QRS vector is perpendicular to the axis of the lead with the equiphasic QRS complex. The equiphasic complex in this tracing is located in lead II. A mean QRS vector of —30° is perpendicular to the axis of lead II but does *not* lie in the preselected quadrant.



If you selected this incorrect response because of a *careless* mistake —*Return to page 74 and select the correct answer.*

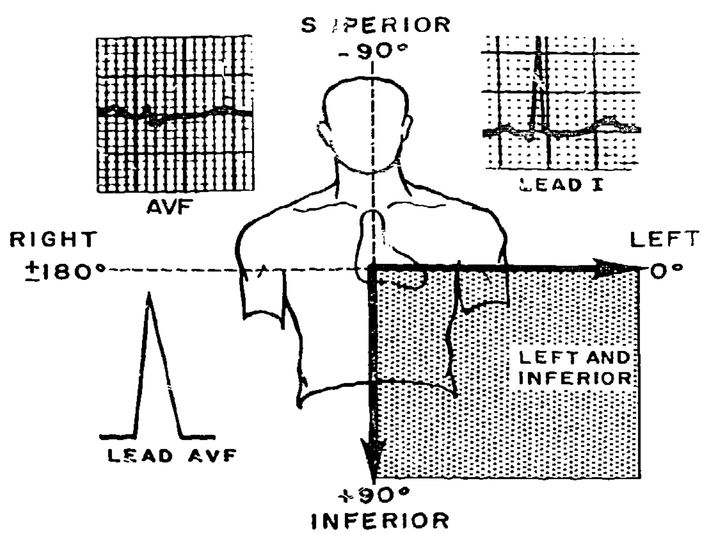
If you do not understand the *basic concept* of the Perpendicular Rule—*Return to page 55 and repeat this material.*

From Page 82

Your answer, LEFT AND INFERIOR, is incorrect.

The predominant upright deflection in lead I indicates net QRS forces are left; this portion of your answer is correct.

If the mean QRS vector were inferior, however, there would be a predominant upright deflection in lead AVF. The QRS complex in lead AVF of this tracing is not predominantly upright.



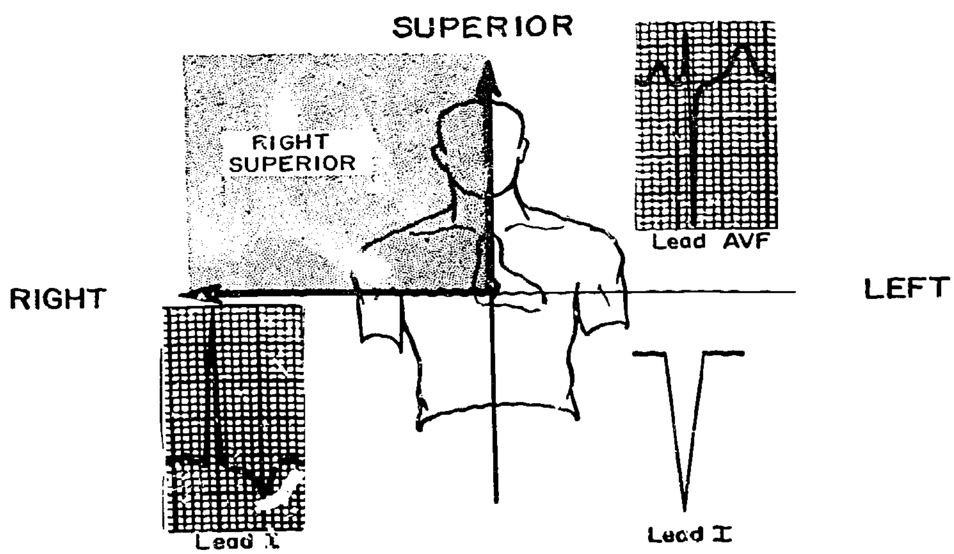
If you selected this incorrect response because of a *careless* mistake —*Return to page 82 and select the correct answer.*

If you do not understand the *basic concept* of the Quadrant Rule— *Return to page 40 and repeat this material.*

From Page 84

Your answer, RIGHT AND SUPERIOR, is incorrect.

The predominant negative deflection in lead AVF indicates net QRS forces are *superior;* this portion of your answer is correct. If the mean QRS vector were right, however, there would be a predominant negative deflection in lead I. A predominant negative deflection is not present in lead I of this tracing.



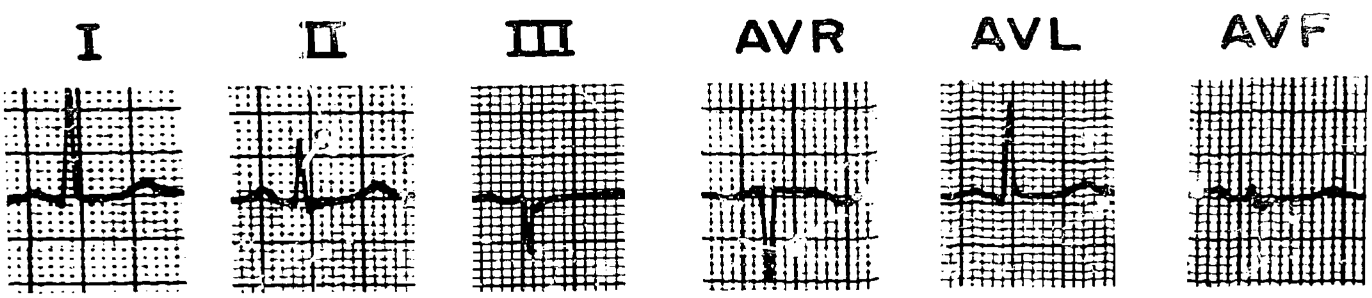
Return to page 84 and choose the correct answer.

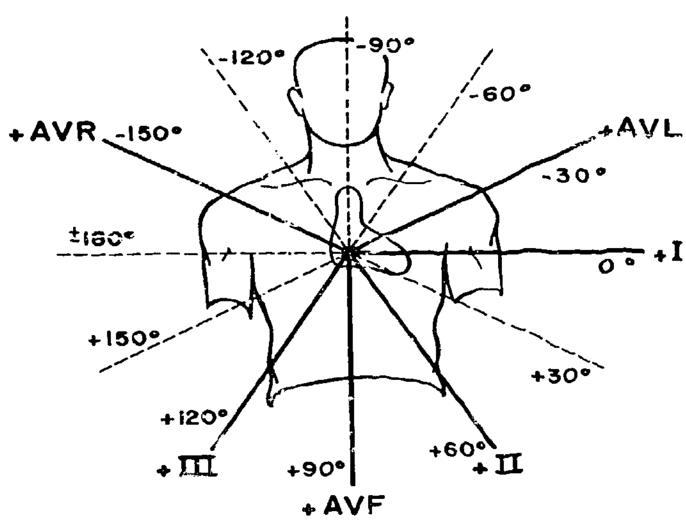
From Page 83

29

Frontal plane leads of an electrocardiogram are presented below. The mean frontal QRS vector is:

LEFT AND NEITHER SUPERIOR NOR INFERIOR	page 78
LEFT AND INFERIOR	page 80
LEFT AND SUPERIOR	page 72



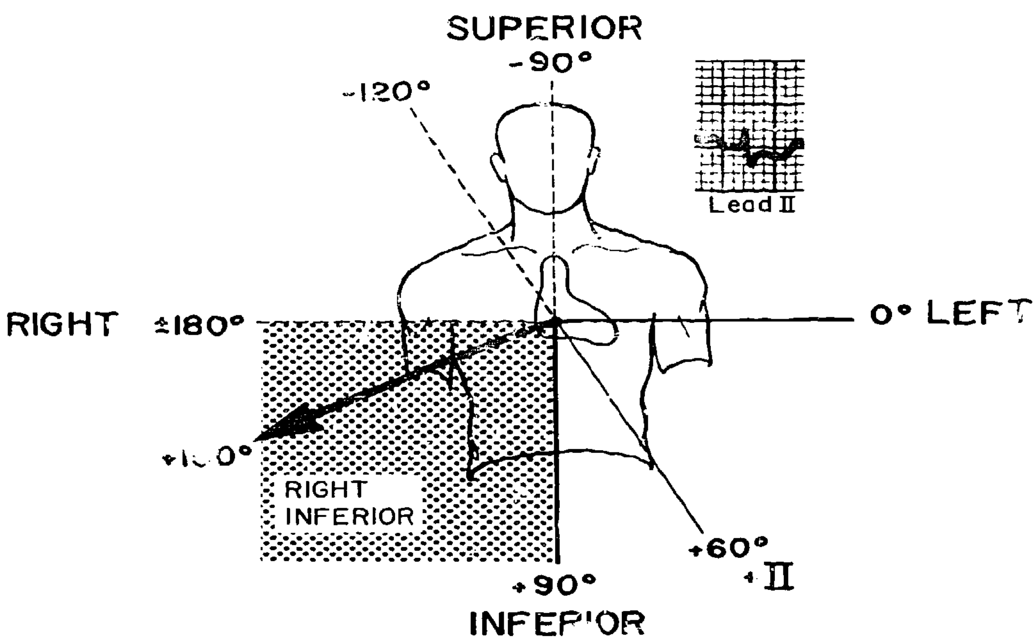


FRONTAL PLANE

From Page 74

Your answer, $+150°$, is correct.

The mean frontal QRS vector is perpendicular to the axis of the lead with the equiphasic complex. The equiphasic complex in this tracing is located in lead II. The mean frontal QRS vector must lie in the preselected right and inferior quadrant perpendicular to the axis of lead II, at $+150°$.



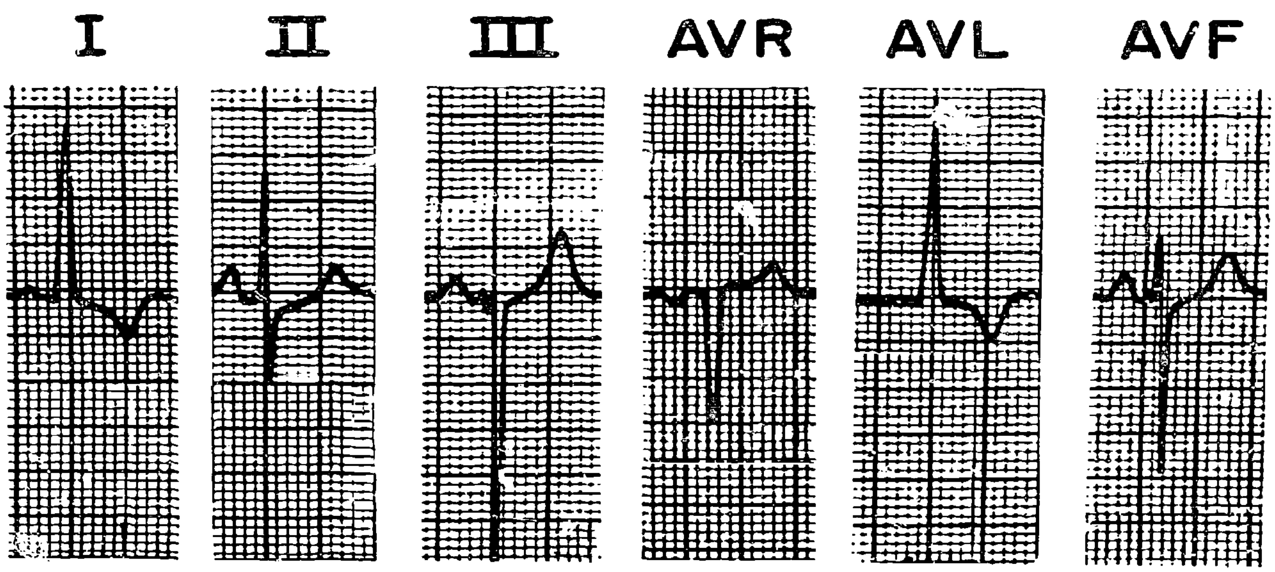
Continue reading on page 82.

From Page 78

30

The mean frontal QRS vector in the electrocardiogram below is:

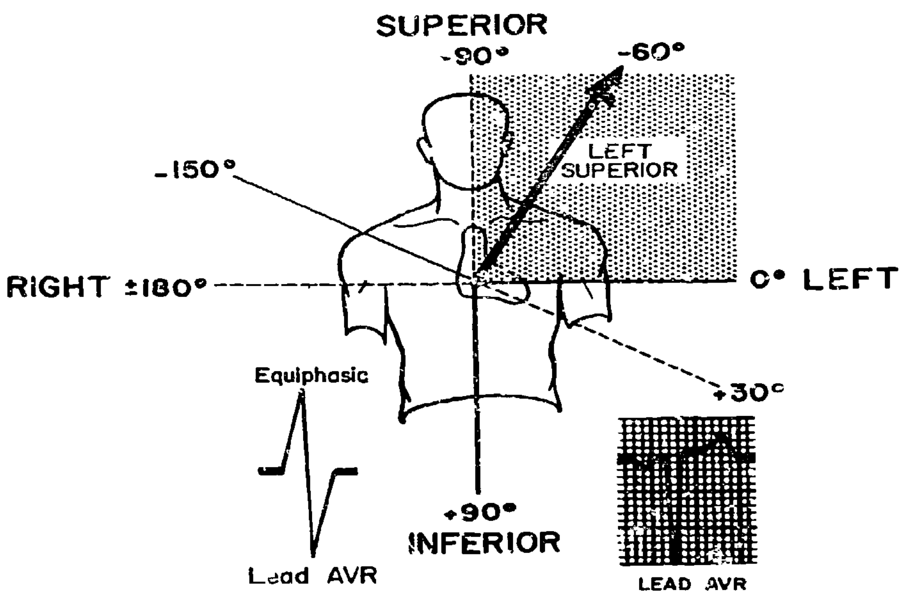
RIGHT AND SUPERIOR	page 81
LEFT AND INFERIOR	page 86
LEFT AND SUPERIOR	page 88



From Page 89

Your answer, $-60°$, is incorrect.

A mean frontal QRS vector left and superior at $-60°$, according to the Perpendicular Rule of Spatial Analysis, demands an equiphasic QRS complex in AVR. The QRS complex in lead AVR of this tracing is not equiphasic.



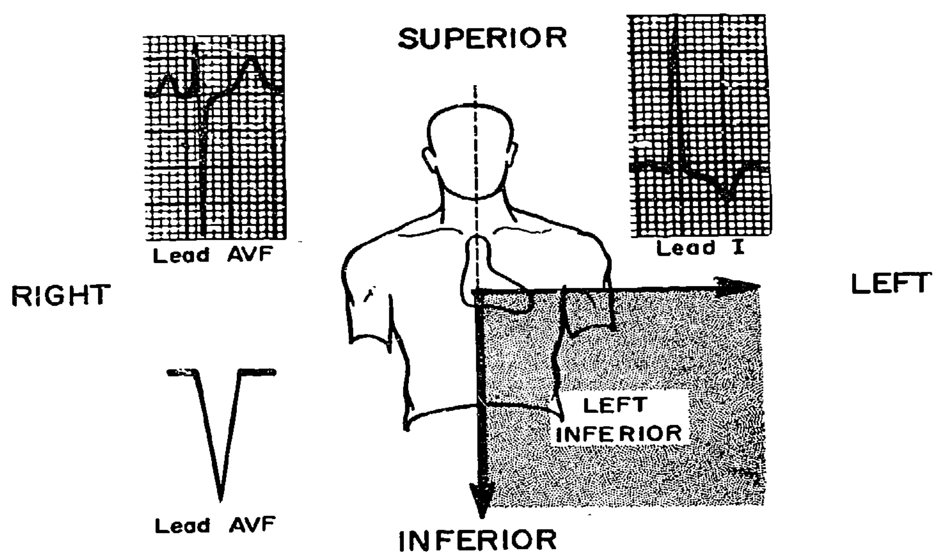
Return to page 89 and choose the correct answer.

From Page 84

Your answer, LEFT AND INFERIOR, is incorrect.

The large upright deflection in lead I indicates net QRS forces are *left:* this portion of your answer is correct.

If the mean QRS vector were inferior, however, there would be a predominant R wave in lead AVF. Lead AVF in this tracing does not present a predominant upright QRS deflection.

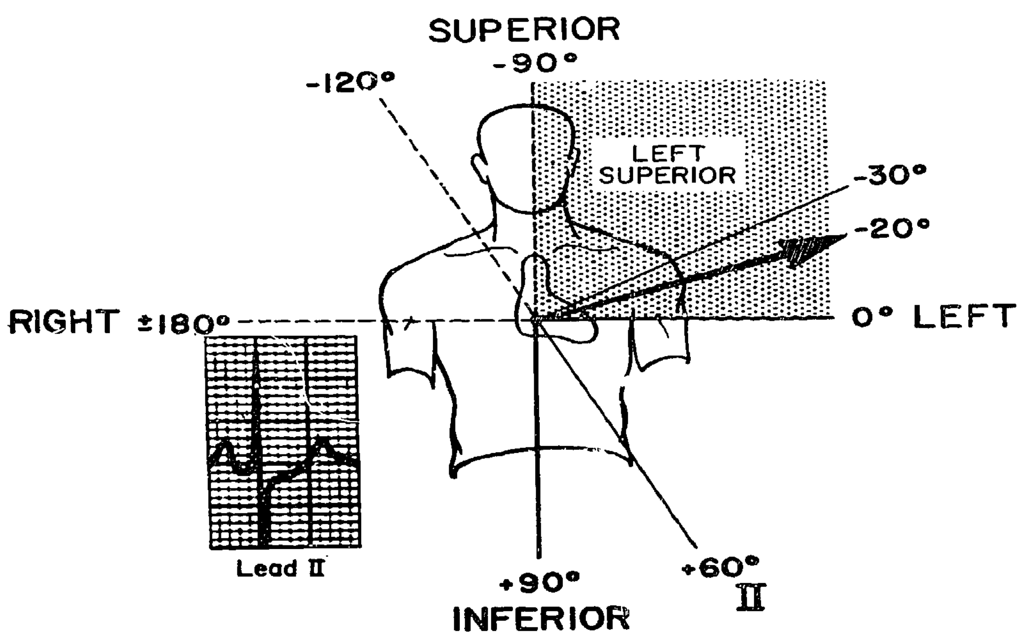


Return to page 84 and choose the correct answer.

From Page 89

Your answer, −20°, is correct.

The Perpendicular Rule of Spatial Analysis states the mean QRS vector is perpendicular to the axis of the lead with the equiphasic complex and in the preselected quadrant. The lead containing the most nearly equiphasic QRS complex in this tracing is lead II. The perpendicular to the axis of lead II in the preselected left and superior quadrant is −30°. Note, however, the upright deflection is slightly larger than the negative deflection. This indicates the mean frontal QRS vector is inclined slightly away from the perpendicular into the *positive field of lead II*. Since the positive field of lead II is oriented toward the left leg, the mean frontal QRS vector must be inclined *slightly more inferior than —30°*, to approximately —20°.



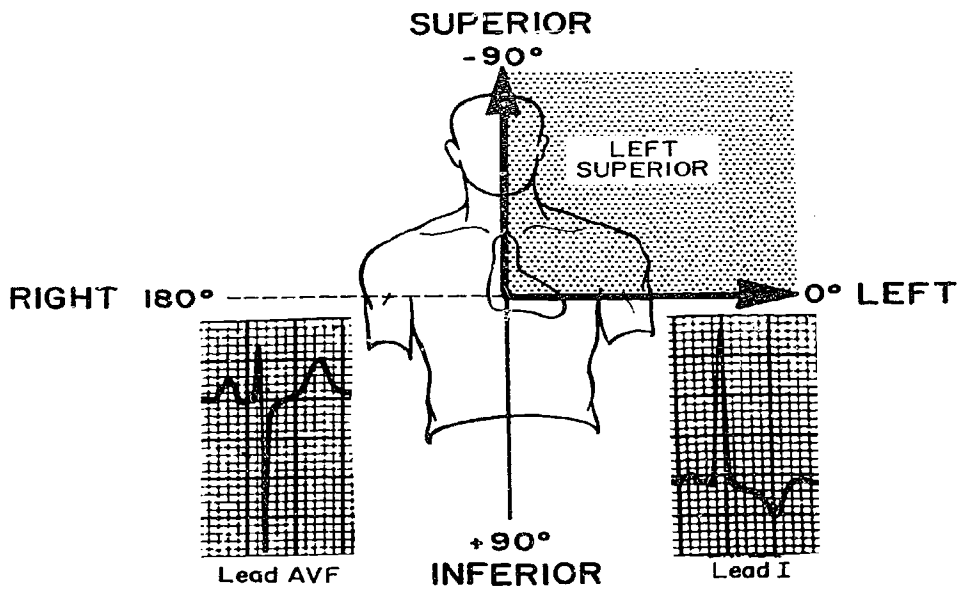
This is a convenient place to pause if you wish.

Begin reading again on page 90.

From Page 84

Your answer, LEFT AND SUPERIOR, is correct.

The large upright deflection in lead I indicates net QRS forces are *left;* the predominant negative deflection in lead AVF indicates net QRS forces are *superior.* The mean frontal QRS vector in this tracing, therefore, lies in the *left and superior quadrant.*



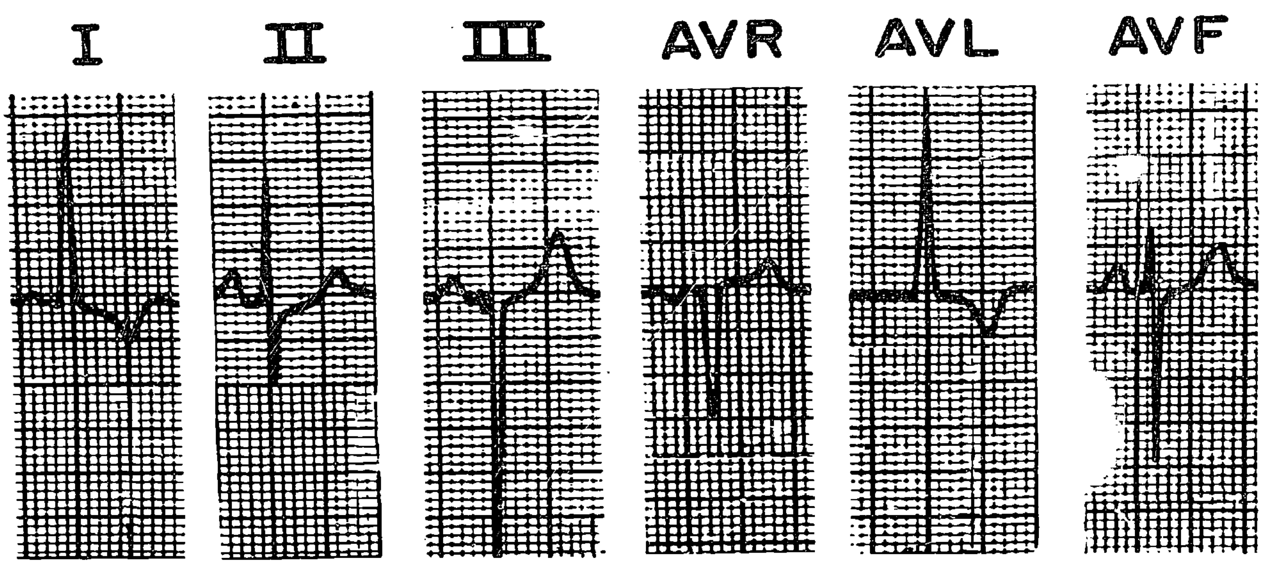
Continue reading on page 89.

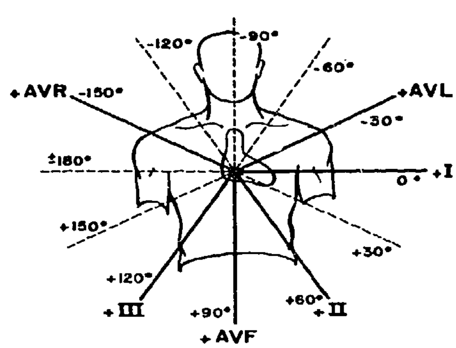
From Page 88

31

The mean frontal QRS vector in this same tracing lies in the left and superior quadrant at:

$-20°$	page 87
$-40°$	page 92
$-60°$	page 85





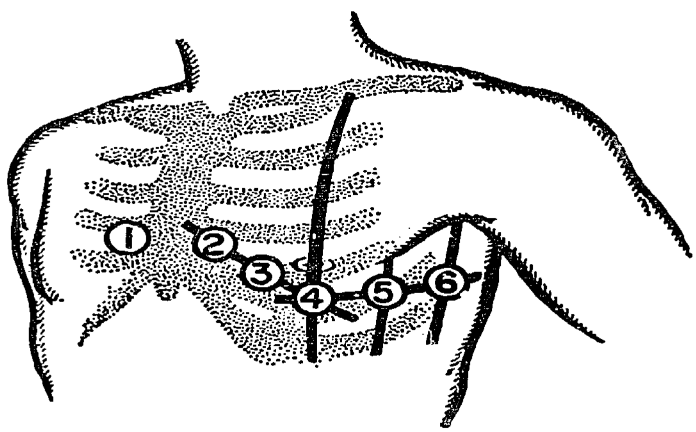
FRONTAL PLANE

From Page 87

SECTION III—MEAN HORIZONTAL QRS VECTOR

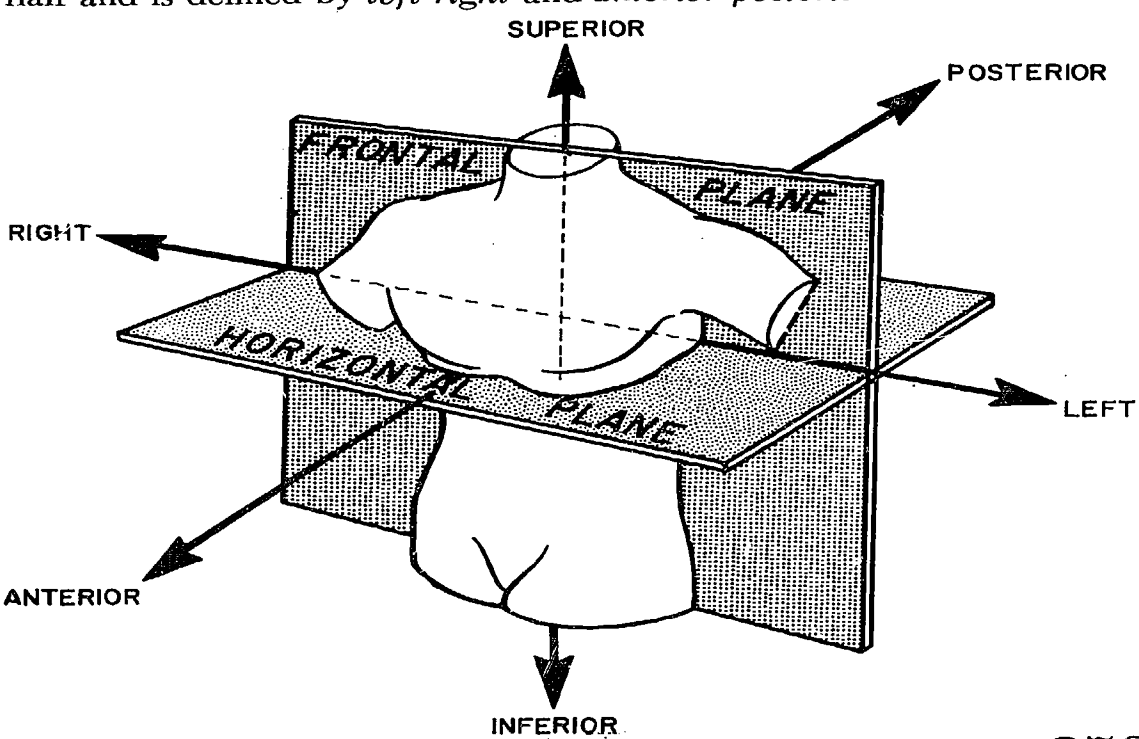
Unipolar chest leads V_1 through V_6 are located on the anterior and lateral aspect of the chest. These locations represent the positive electrodes of the chest leads. The negative electrode for these leads is a central terminal assumed to be located within the heart.

The locations of these electrodes define the horizontal plane through the heart at the level of the fifth interspace. Chest leads, therefore, lie in the horizontal plane of the body.



The *frontal* plane divides the body into a front and back half and is defined by *left-right* and *superior-inferior* axes.

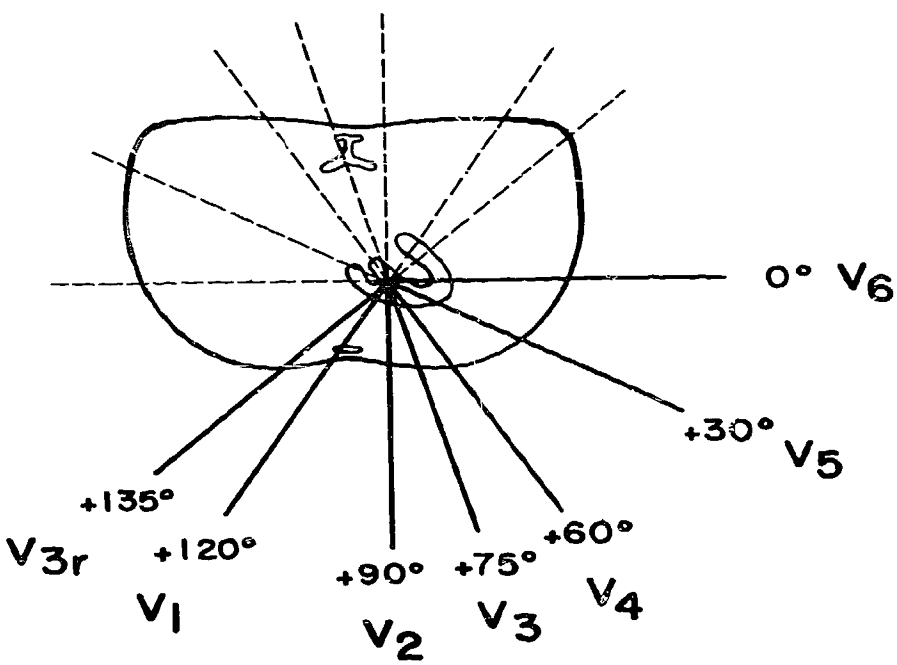
The *horizontal* plane divides the body into an upper and lower half and is defined by *left-right* and *anterior-posterior* axes.



Please continue reading on page 91.

From Page 90

The positive electrodes of the leads V_1 through V_6 may be located on a diagram representing a transverse section through the heart at the level of the fifth interspace. The axes of these chest leads in degrees also may be added. The negative portion of each lead axis lies 180° opposite the positive portion. This resulting figure is known as the *Horizontal Plane Reference Figure*.



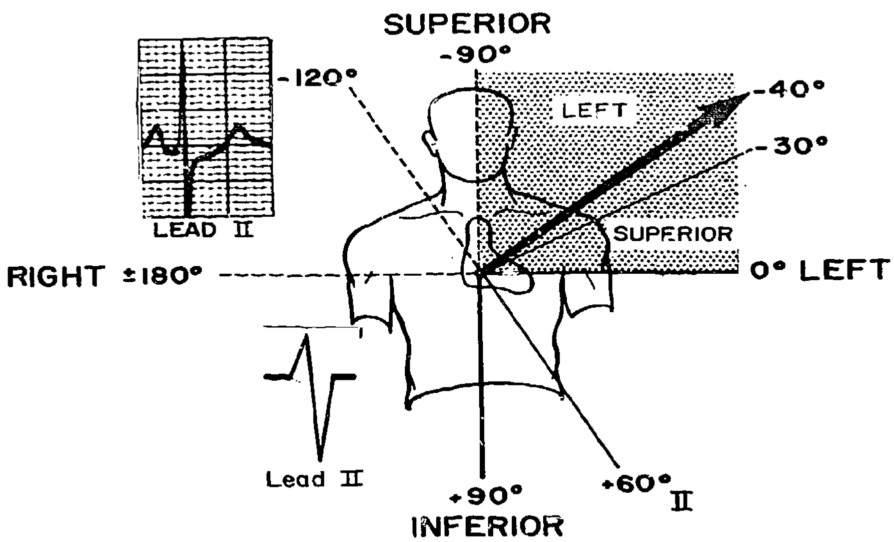
HORIZONTAL PLANE

Continue reading on page 93.

From Page 89

Your answer, $-40°$, is incorrect.

The Perpendicular Rule of Spatial Analysis states the mean frontal QRS vector lies perpendicular to the axis of the lead with the equiphasic complex and in the preselected quadrant. The lead with the most nearly equiphasic QRS complex is lead II. The perpendicular to the axis of lead II in the preselected left and superior quadrant is $-30°$. However, $-40°$ lies slightly superior to $-30°$ and is in the negative field of lead II. This requires a slightly larger negative than upright deflection in lead II. The QRS deflection in lead II in this tracing does not display a larger negative than upright deflection.



Return to page 89 and choose the correct answer.

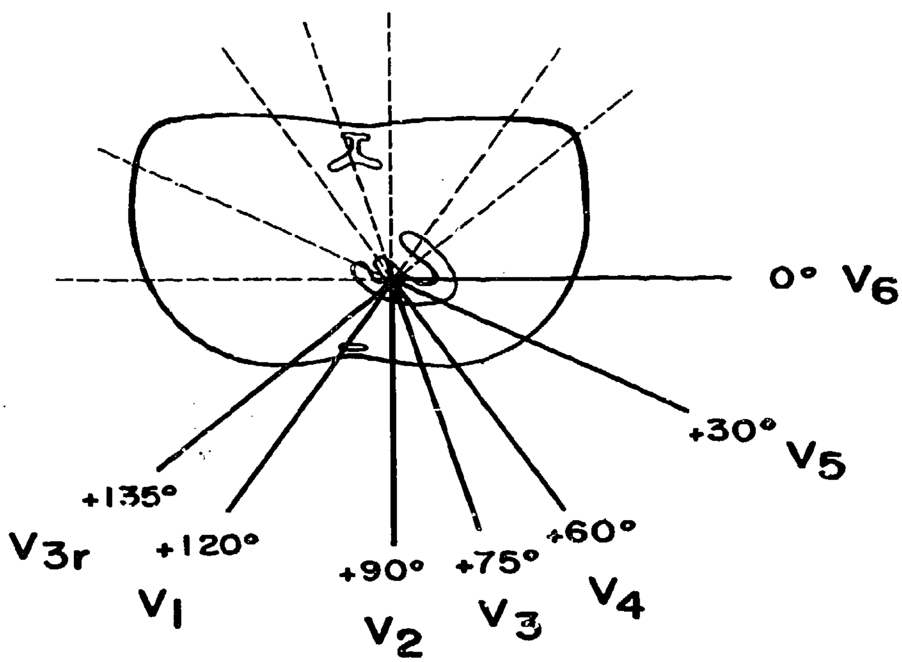
From Page 91

32

The Horizontal Plane Reference Figure illustrates chest leads, the positive electrode locations, and the axis of each lead in degrees. Utilizing this reference figure it is possible to select the leads best representing left-right and anterior-posterior voltage changes in the horizontal plane.

The best *left-right* lead in the horizontal plane is lead:

V_6	page 104
V_5	page 99
V_2	page 101

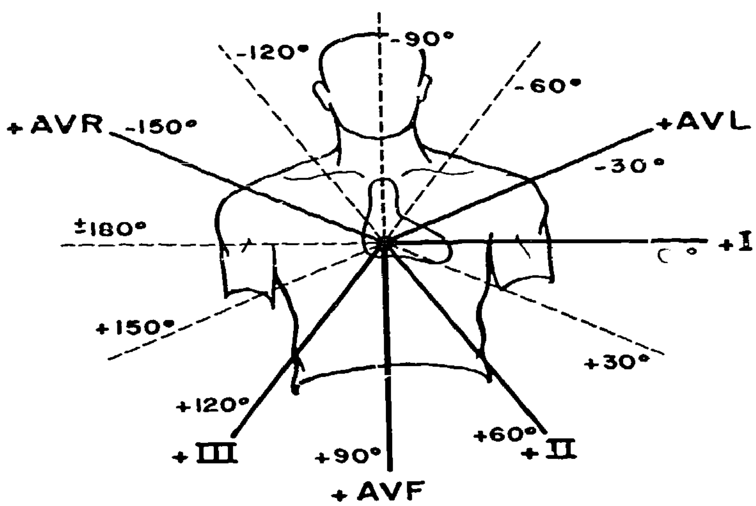


HORIZONTAL PLANE

From Page 103

Your answer, LEADS I and AVF, is incorrect.

Lead I represents left-right voltage changes; however, lead AVF represents superior-inferior voltage changes and does not lie in the horizontal plane.



FRONTAL PLANE

Return to page 103 and choose the correct answer.

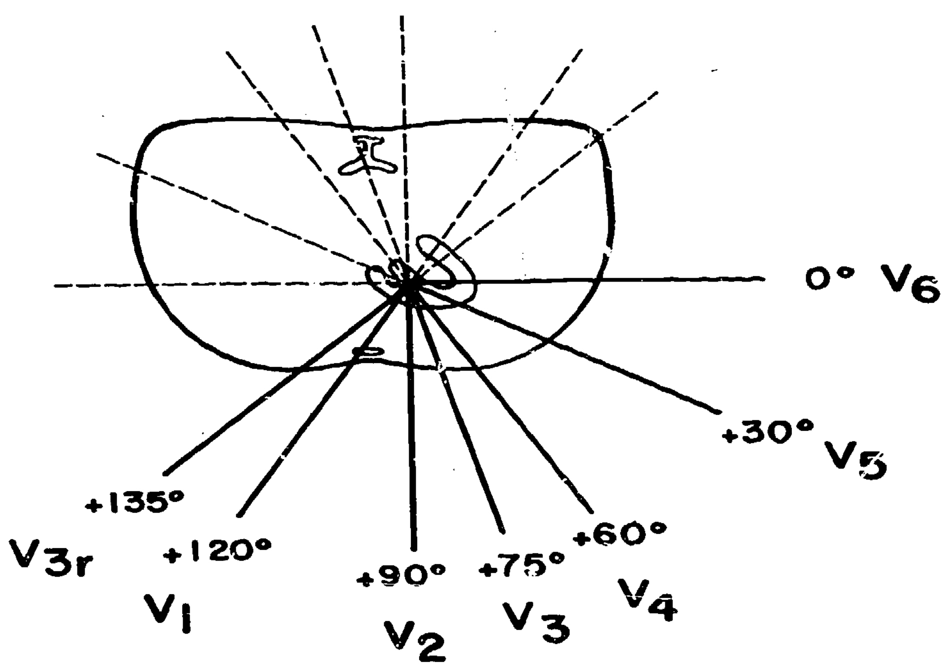
From Page 104

33

Utilizing the horizontal plane reference figure it is possible to select the horizontal plane leads best representing left-right and anterior-posterior voltage changes.

The lead best representing voltage changes along the anterior-posterior axis is lead:

V_1	page 97
V_2	page 102
V_6	page 106

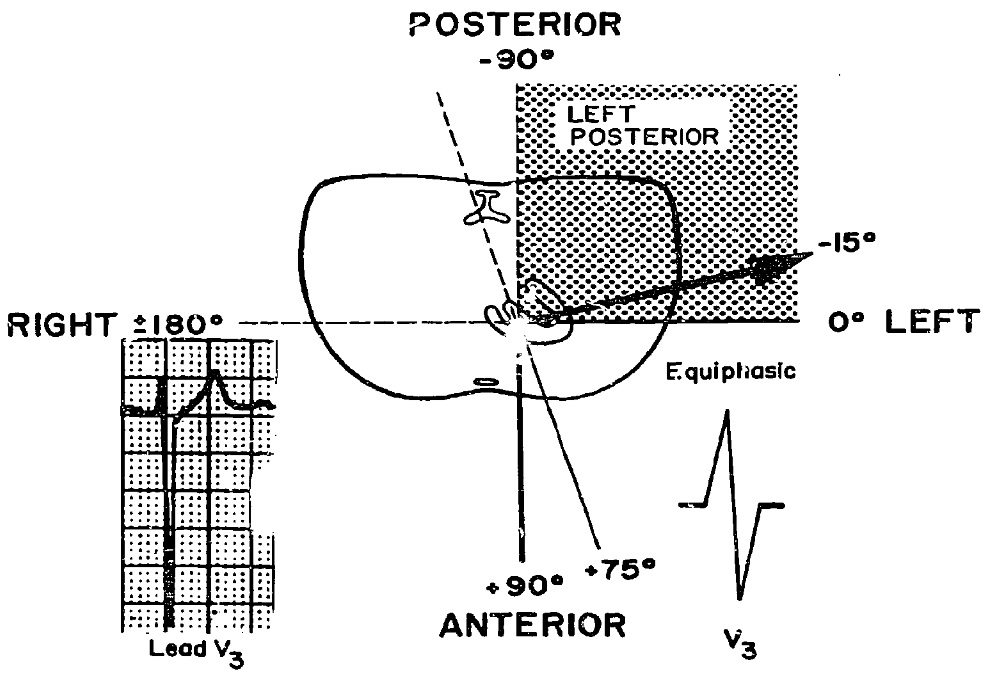


HORIZONTAL PLANE

From Page 113

Your answer, -15°, is incorrect.

A mean horizontal QRS vector at -15° demands an equiphasic complex in lead V_3. Lead V_3 in this tracing does not present an equiphasic complex.

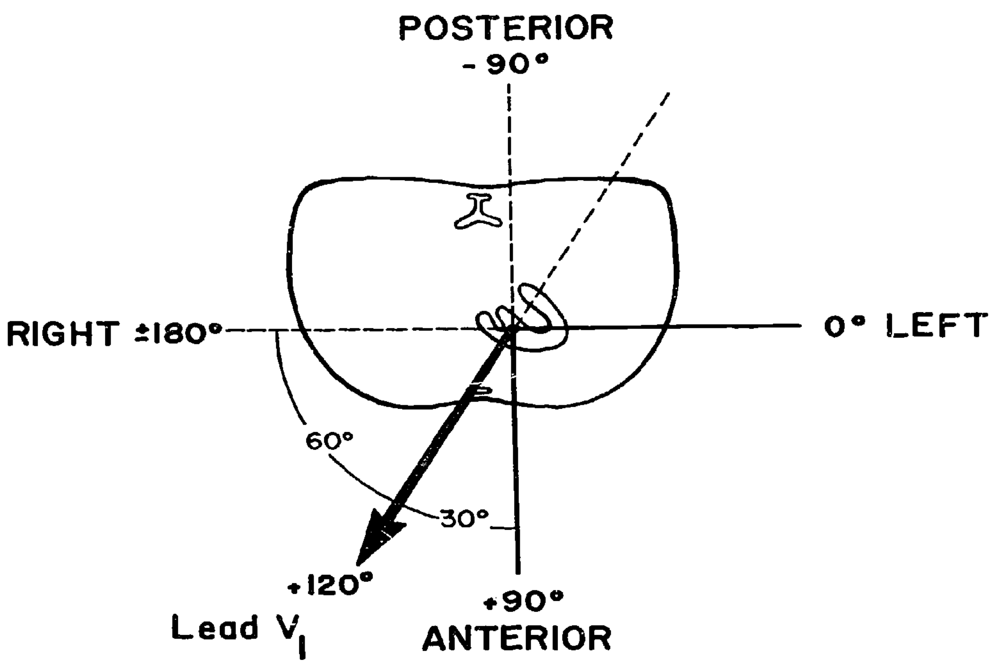


Return to page 113 and choose the correct answer.

From Page 95

Your answer, V_1, is partially correct.

The positive portion of the lead V_1 axis, according to the horizontal plane reference figure, is located right and anterior at +120°. Lead V_1 is primarily an anterior-posterior lead with a left-right tilt. In actual practice, however, lead V_1 often is utilized as an anterior-posterior lead similar to lead V_2 if the configuration is different in these two leads. Experience aids in selecting which lead is best utilized for spatial analysis. Your answer is partially correct; a better answer to this question is available.



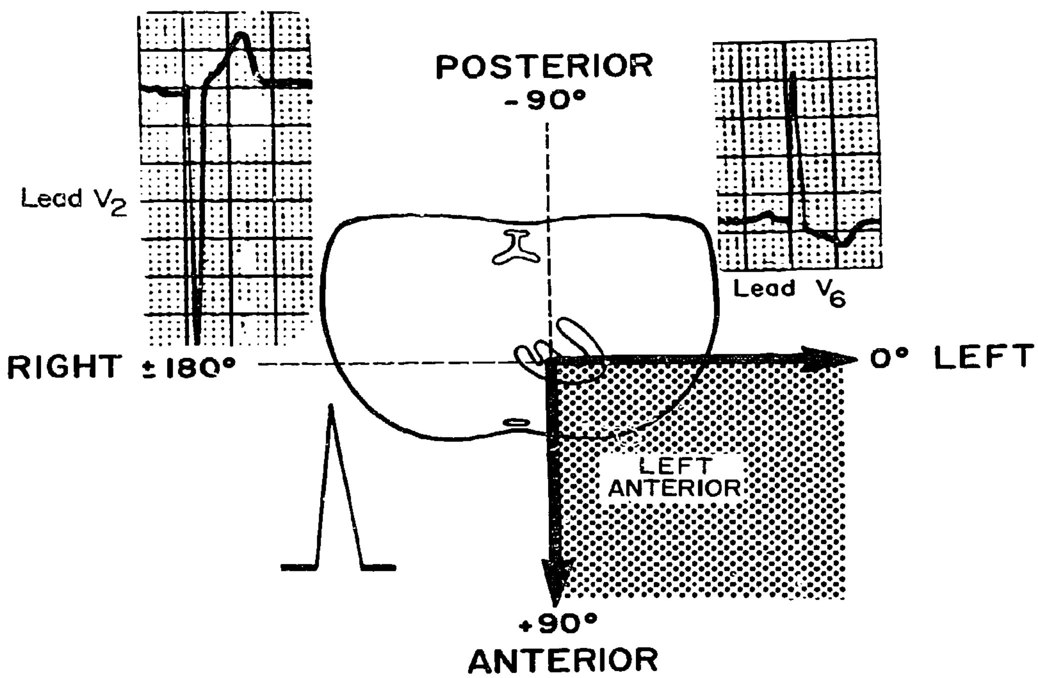
Return to page 95 and choose the correct answer.

From Page 107

Your answer, LEFT AND ANTERIOR, is incorrect.

The predominant upright deflection in lead V_6 indicates the mean horizontal QRS vector is *left;* this portion of your answer is correct.

An anterior mean horizontal QRS vector, however, demands a net upright deflection in lead V_2. A net *upright deflection* is not displayed in lead V_2 of this tracing.

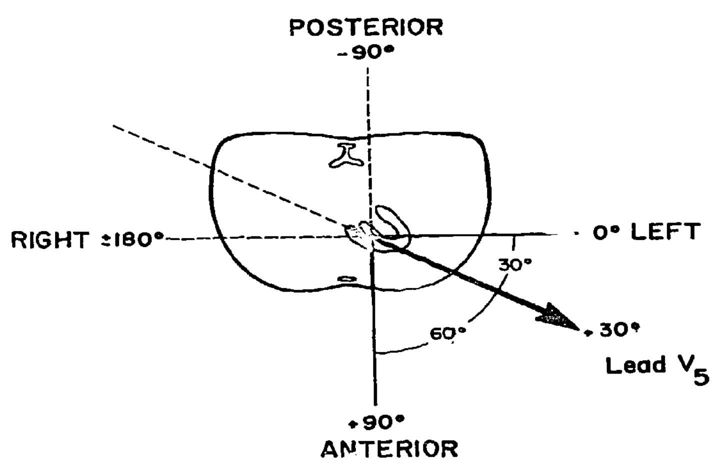


Turn to page 107 and choose the correct answer.

From Page 93

.. ·r answer, V_5, is incorrect.

The positive portion of the lead V_5 axis is *left and anterior at +30°.* Lead V_5 is primarily a left-right lead with an anterior-posterior tilt. Lead V_5, therefore, is not the best left-right lead.

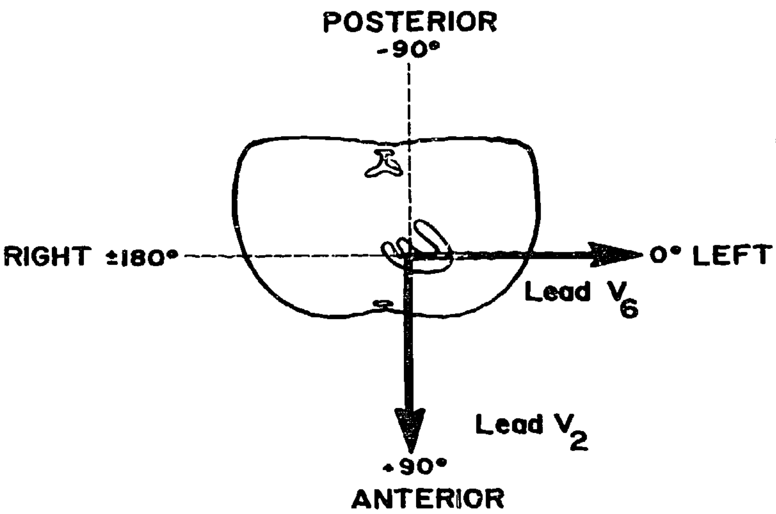


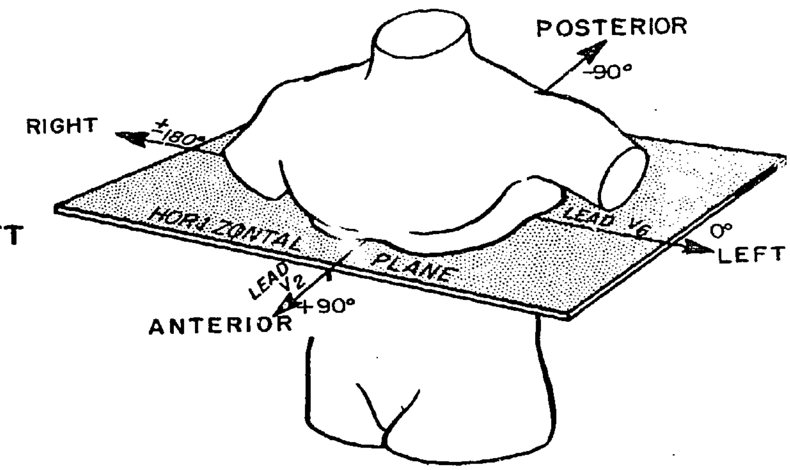
Return to page 93 and choose the correct answer.

From Page 103

Your answer, LEADS V_2 and V_6, is correct.

The positive portion of the lead V_2 axis is *anterior at* $+90°$; the positive portion of the lead V_6 axis is *left at* $0°$. These leads represent "pure" anterior-posterior and left-right leads. Combining voltage changes along these axes will localize the mean horizontal QRS vector to a quadrant.





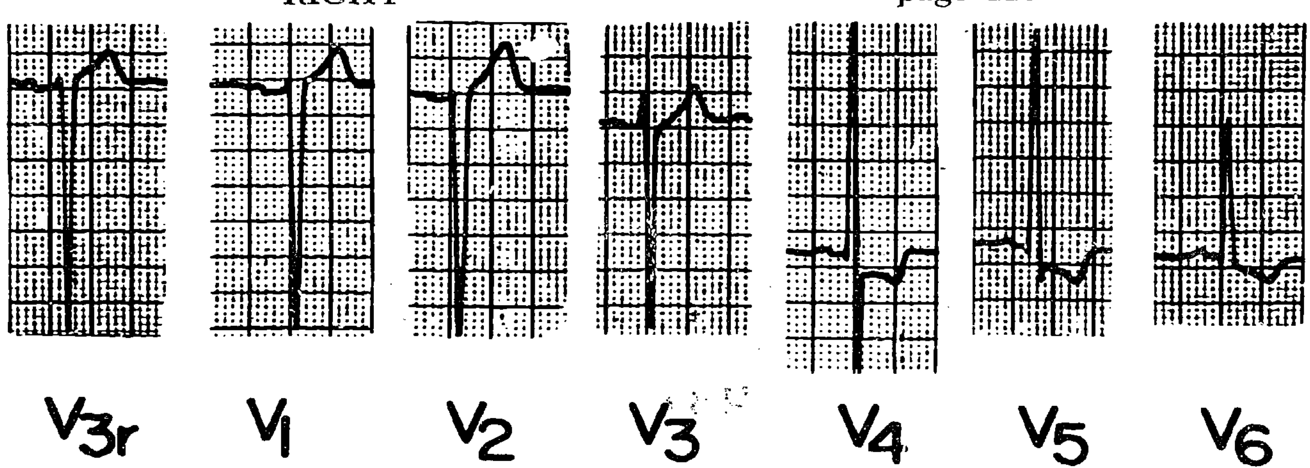
35

The mean horizontal QRS vector may be determined similar to the mean frontal QRS vector by the Quadrant and Perpendicular Rules of Spatial Analysis.

The net QRS forces along the left-right axis in the horizontal plane of this tracing are:

LEFT — page 114

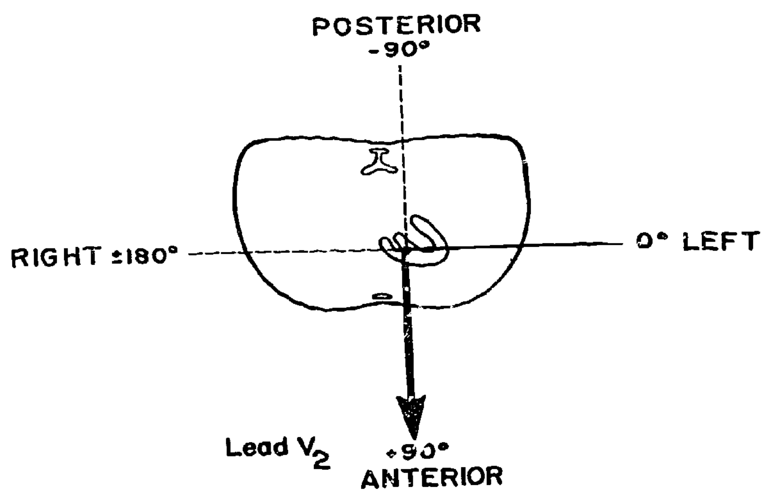
RIGHT — page 110



From Page 93

Your answer, V_2, is incorrect.

The positive portion of the lead V_2 axis is locat[illegible] anterior at $+90°$; lead V_2, therefore, is not a left-right lead.



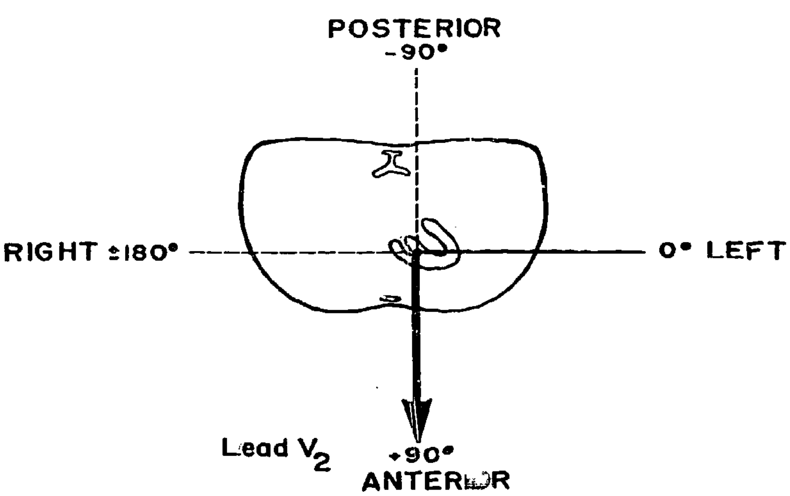
Return to page 93 and choose the correct answer.

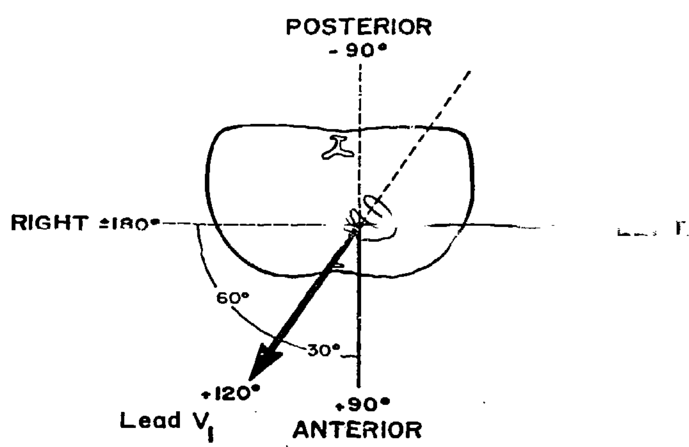
From Page 95

Your answer, V_2, correct.

The positive portion of the lead V_2 axis, according to the horizontal plane reference figure, is anterior at $+90°$. Lead V_2 is a "pure" anterior-posterior lead without left-right tilt.

The positive portion of the lead V_1 axis is anterior and slightly right at $+120°$. Lead V_1 often is identical in configuration to lead V_2; lead V_1 may be utilized as an anterior-posterior lead. Should leads V_1 and V_2 differ, lead V_1 may be more accurate as an anterior-posterior lead. *Experience* only can dictate which lead is the more appropriate anterior-posterior lead.





Continue reading on page 103.

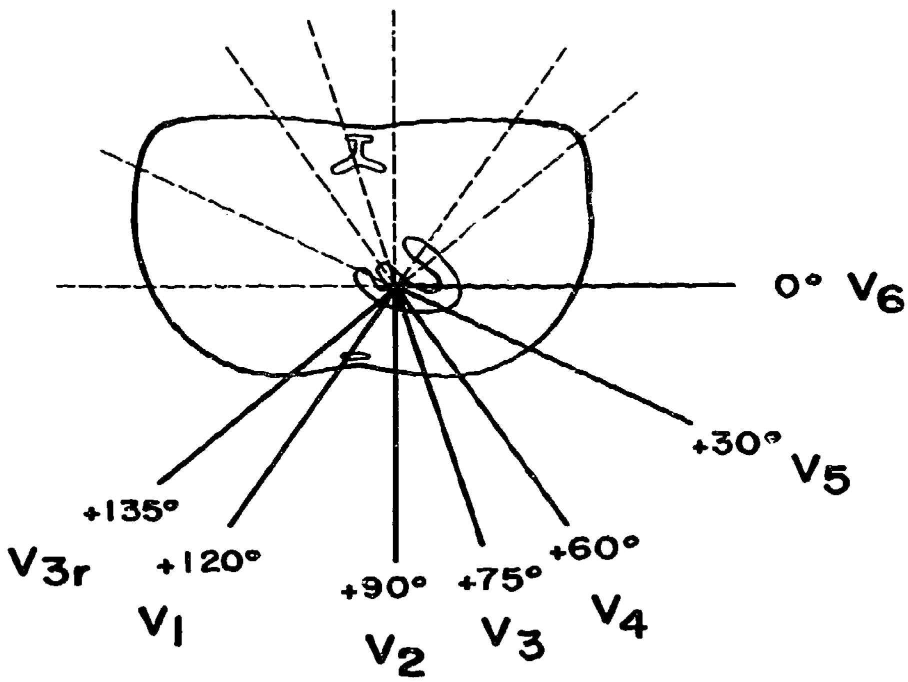
From Page 102

34

The mean horizontal QRS vector may be determined from the net QRS forces along the left-right and anterior-posterior axes of the body.

The best horizontal plane leads to determine mean horizontal QRS vectors are:

LEADS I AND AVF	page 94
LEADS V_2 and V_6	page 100
LEADS AVR, AVL and AVF	page 105



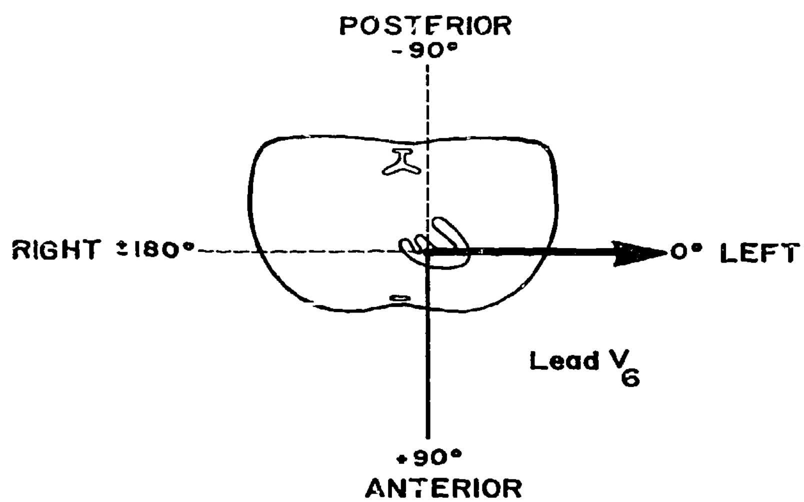
HORIZONTAL PLANE

From Page 93

Your answer, V_6, is correct.

The positive portion of the lead V_6 axis is *left at 0°;* lead V_6, therefore, is a "pure" left-right lead without anterior-posterior tilt.

Lead V_6 is the best left-right lead in the horizontal plane; lead I is the best left-right lead in the frontal plane. For spatial analysis, either lead V_6 or lead I may be utilized as a left-right lead provided both leads are similar in configuration. If leads I and V_6 are dissimilar, it is best to utilize lead I since it is a more "distant" lead and not subject to errors in electrode positioning.

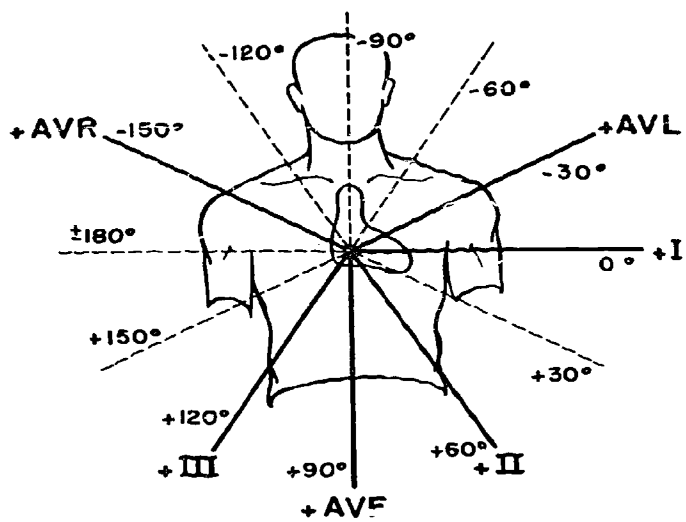


Continue reading on page 95.

From Page 103

Your answer, LEADS AVR, AVL, and AVF, is incorrect.

Leads AVR, AVL, and AVF are frontal plane leads and do not represent voltage changes in the horizontal plane.



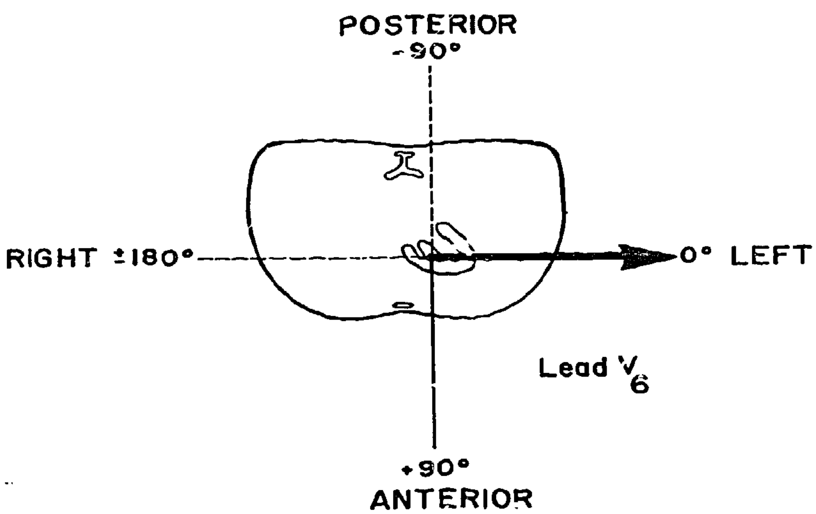
FRONTAL PLANE

Return to page 103 and choose the correct answer.

From Page 95

Your answer, V_6, is incorrect.

The positive portion of the lead V_6 axis is located left at 0°. Lead V_6, therefore, is not an anterior-posterior lead.

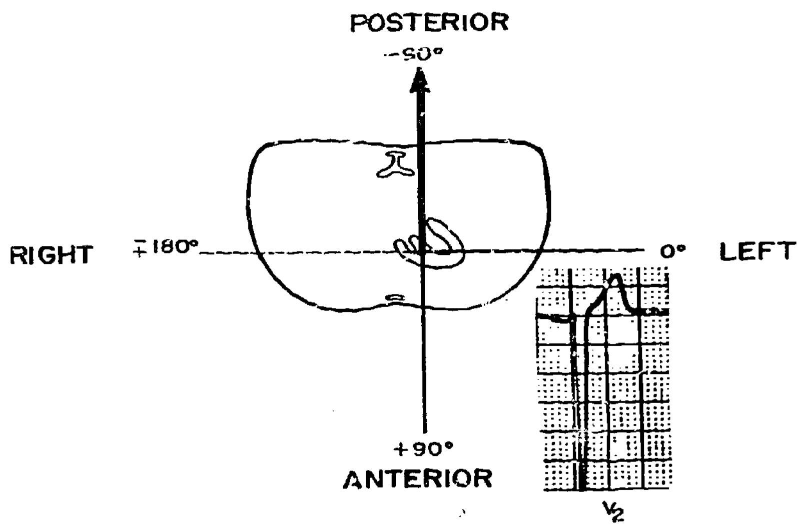


Return to page 95 and choose the correct answer.

From Page 114

Your answer, POSTERIOR, is correct.

The predominant QRS deflection in lead V_2 is *negative*, indicating net QRS forces are *posterior*.



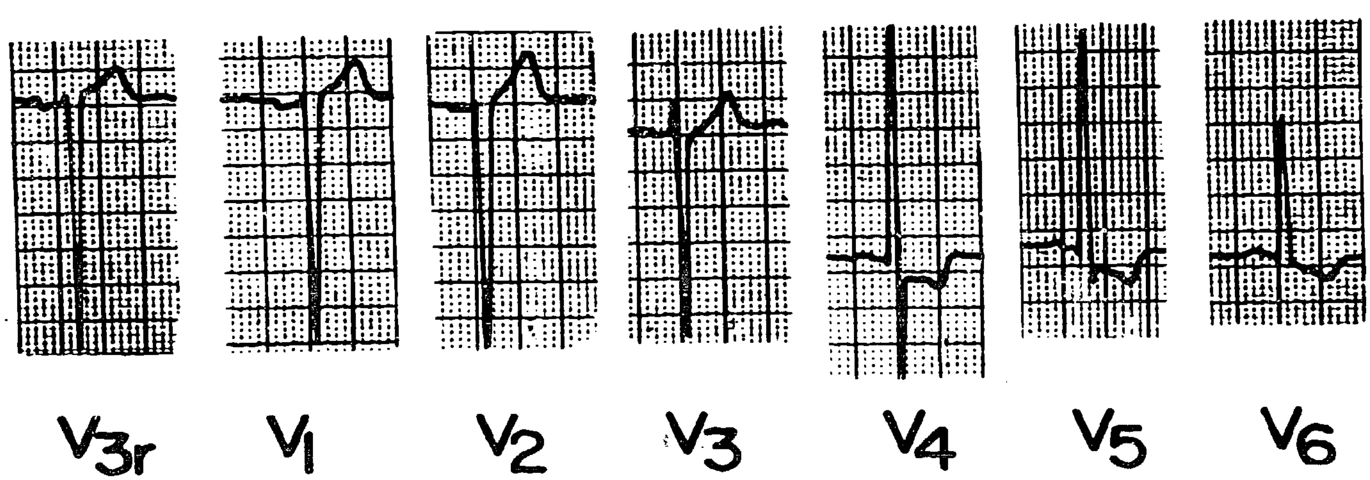
37

Utilizing the Quadrant Rule of Spatial Analysis, the mean horizontal QRS vector in this tracing may be localized:

RIGHT AND POSTERIOR page 112

LEFT AND POSTERIOR page 111

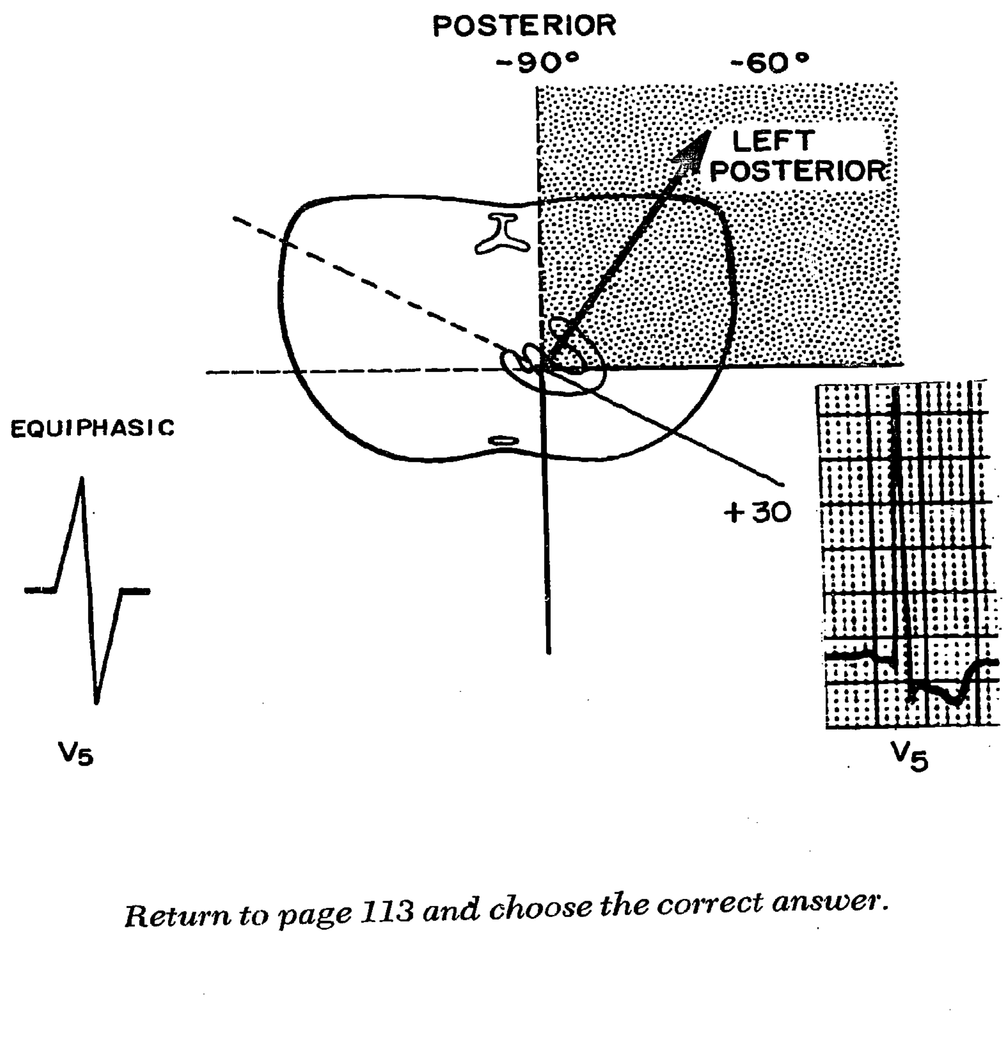
LEFT AND ANTERIOR page 98



From Page 113

Your answer, -60°, is incorrect.

A mean horizontal QRS vector at -60° demands an equiphasic complex in lead V_5. Lead V_5 in this tracing does not present an equiphasic complex.

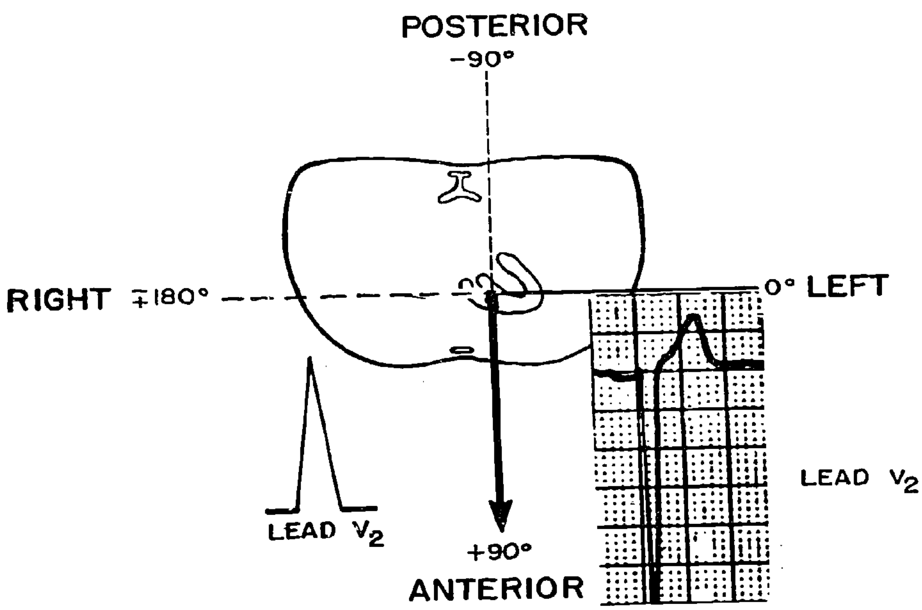


Return to page 113 and choose the correct answer.

From Page 114

Your answer, ANTERIOR, is incorrect.

Net *anterior QRS forces* demand a predominant *positive* deflection in lead V_2. Lead V_2 in this tracing does not have a predominantly upright deflection.

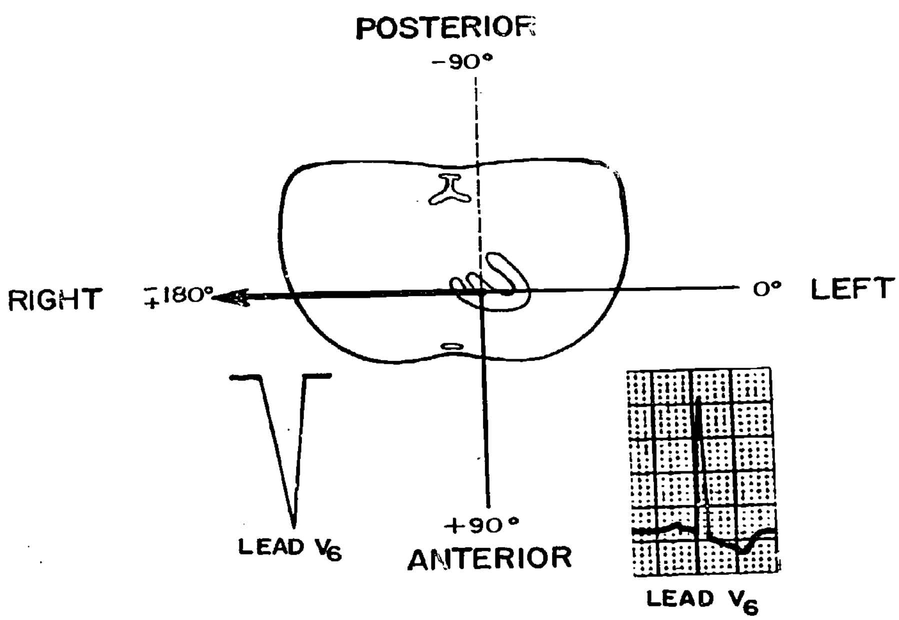


Return to page 114 and choose the correct answer.

From Page 100

Your answer, RIGHT, is incorrect.

Rightward QRS forces in the horizontal plane demand a predominant *negative deflection* in the left-right lead, V_6. The QRS complex in lead V_6 in this tracing is not predominantly negative.

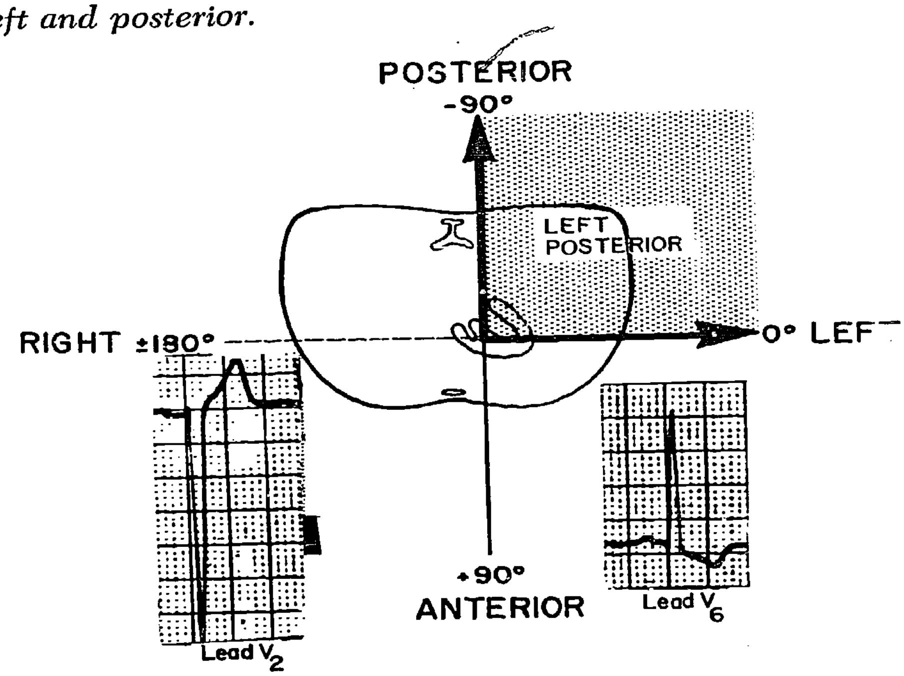


Return to page 100. Choose the correct answer.

From Page 107

Your answer, LEFT AND POSTERIOR, is correct.

The predominant upright deflection in lead V_6 indicates the mean horizontal QRS vector is *left;* the predominant negative deflection in lead V_2 indicates net QRS forces are *posterior*. The mean horizontal QRS vector, therefore, according to the Quadrant Rule, must be localized *left and posterior.*

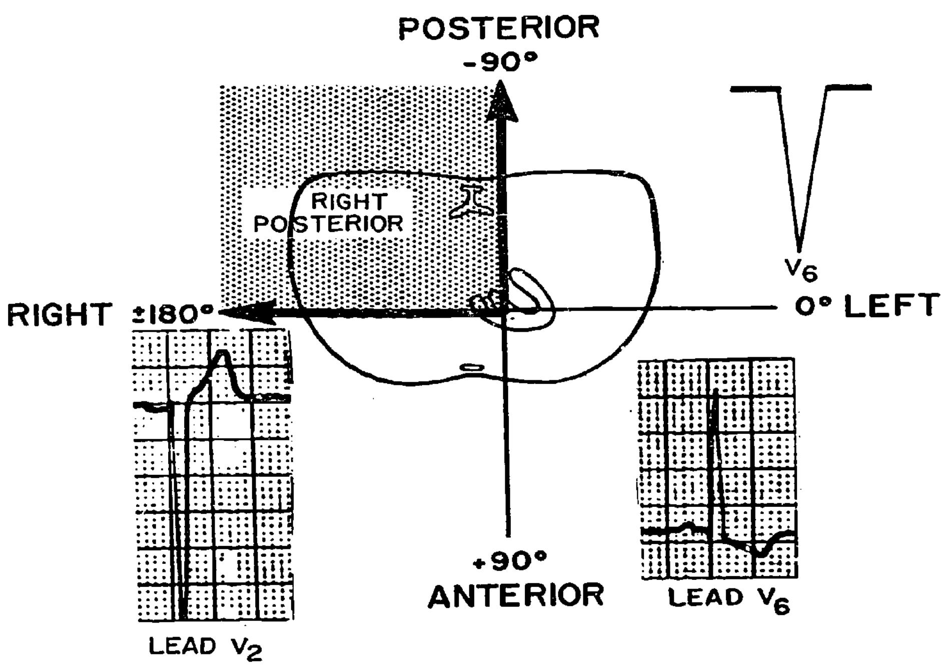


Continue reading on page 113.

From Page 107

Your answer, RIGHT AND POSTERIOR, is incorrect.

The predominant negative deflection in lead V_2 indicates the mean horizontal QRS vector is posterior; a mean rightward QRS vector, however, demands a predominant negative deflection in the left-right lead, V_6. A predominant negative QRS deflection is not present in lead V_6 of this tracing.



Return to page 107 and choose the correct answer.

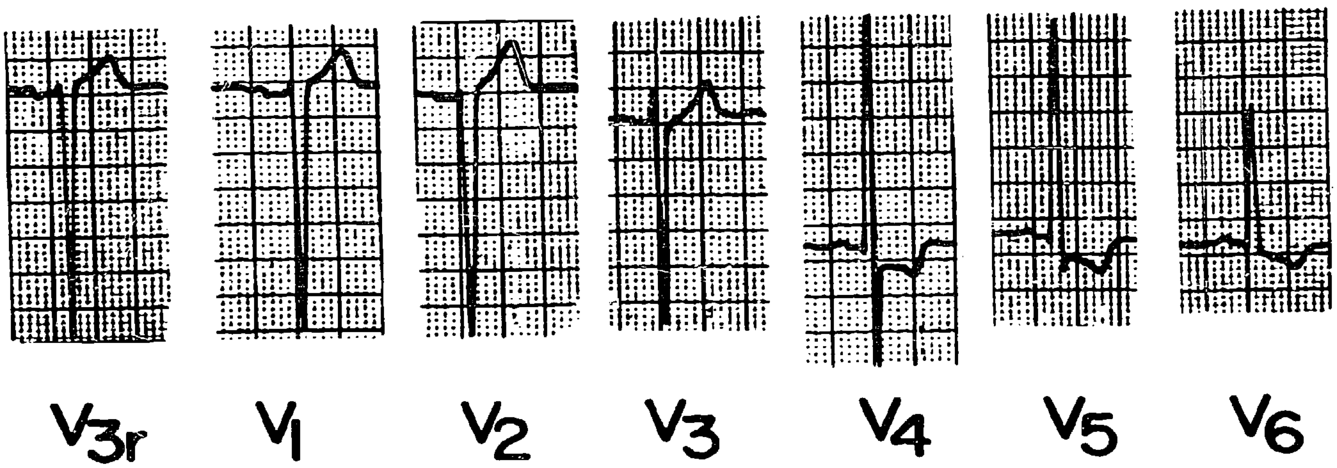
From Page 111

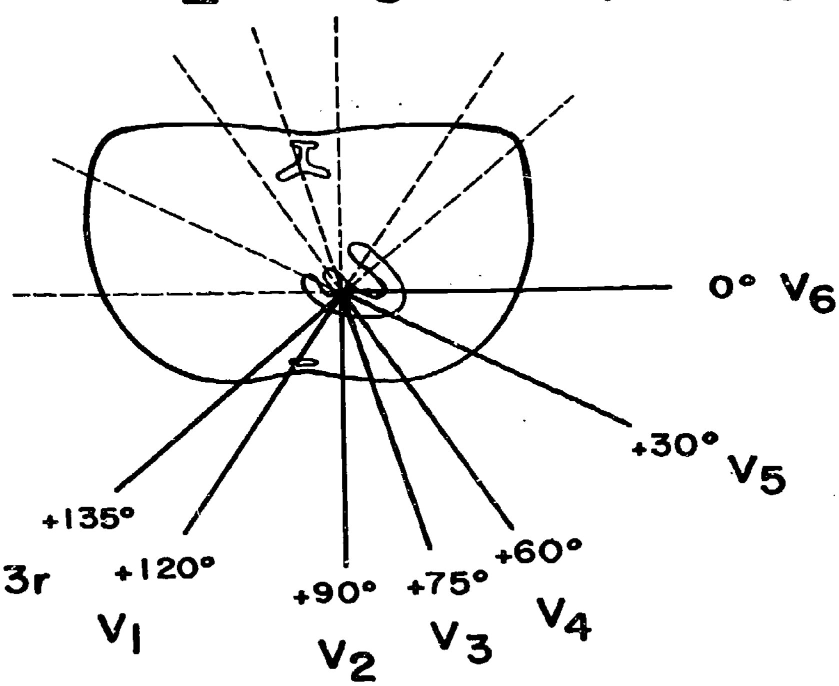
38

The mean horizontal QRS vector may be fixed in degrees by the Perpendicular Rule of Spatial Analysis.

The mean horizontal QRS vector in this tracing is left and posterior at:

−15°	page 96
−30°	page 116
−60°	page 108



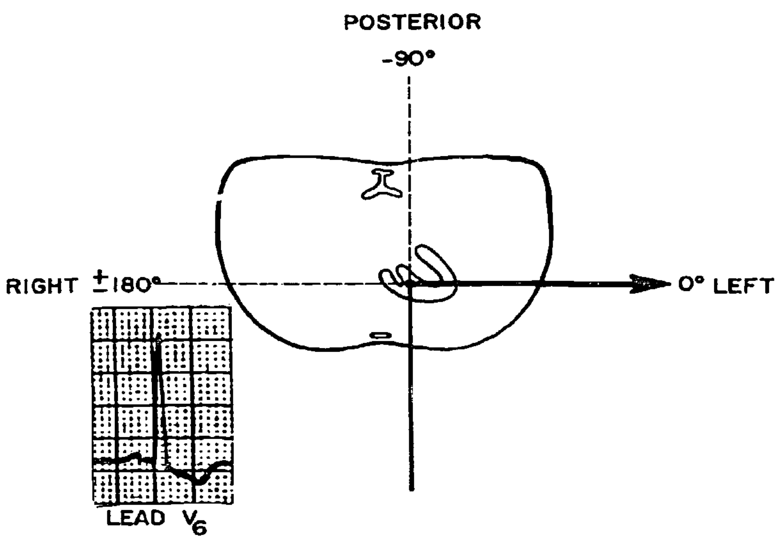


HORIZONTAL PLANE

From Page 100

Your answer, LEFT, is correct.

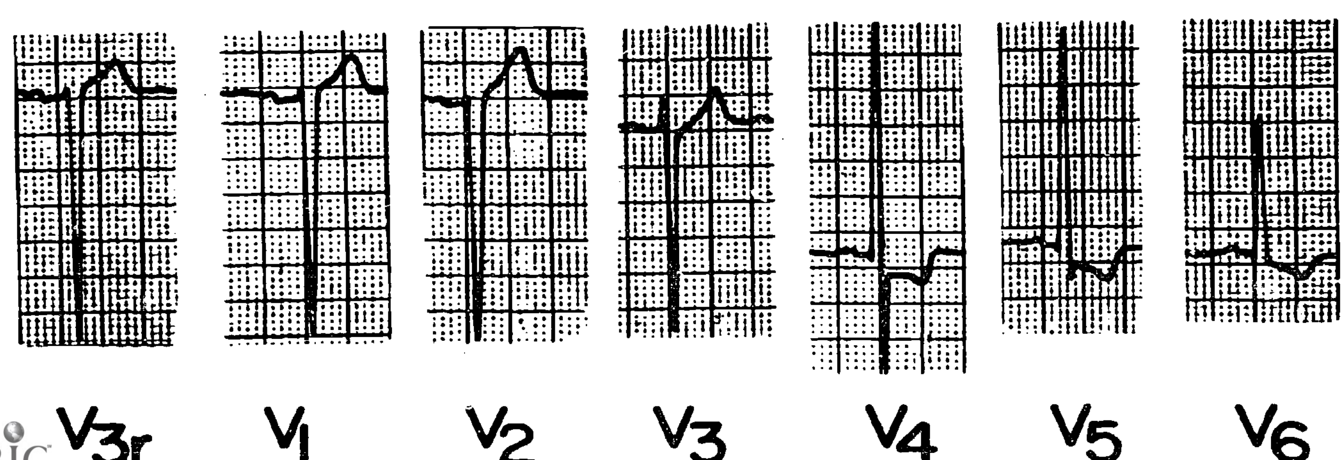
The predominant upright QRS deflection in lead V_6 indicates the net QRS forces are left.



36

Net QRS forces along the anterior-posterior axis of this tracing are:

ANTERIOR	page 109
POSTERIOR	page 107

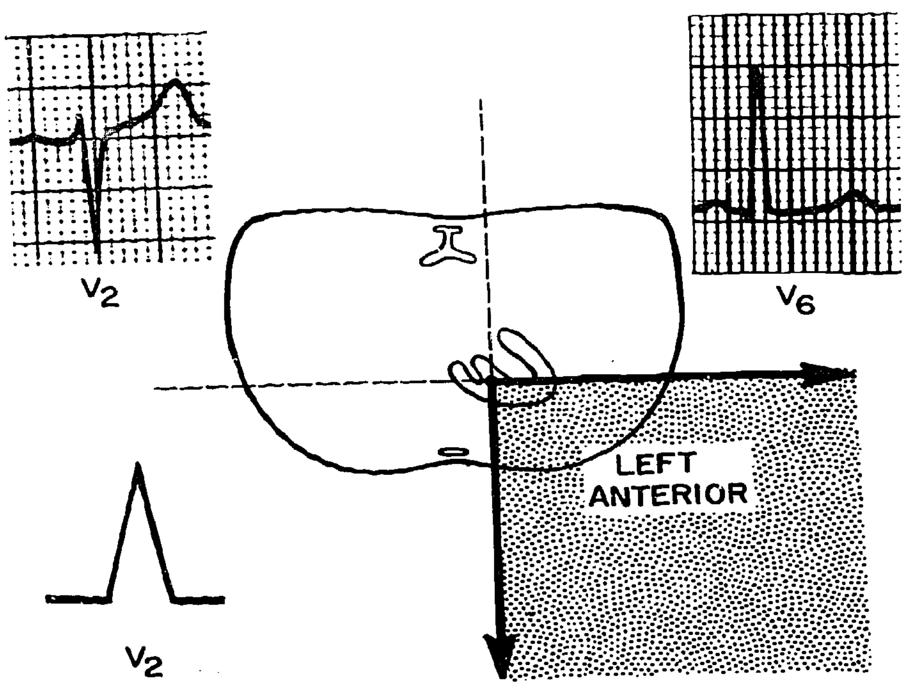


From Page 118

Your answer, LEFT AND ANTERIOR, is incorrect.

The predominant upright deflection in lead V_6 of this tracing indicates net QRS forces are left: this portion of your answer is correct.

An anterior mean QRS vector, however, demands a predominant *upright* deflection in the anterior-posterior lead, V_2. The QRS complex in lead V_2 is not predominantly upright.

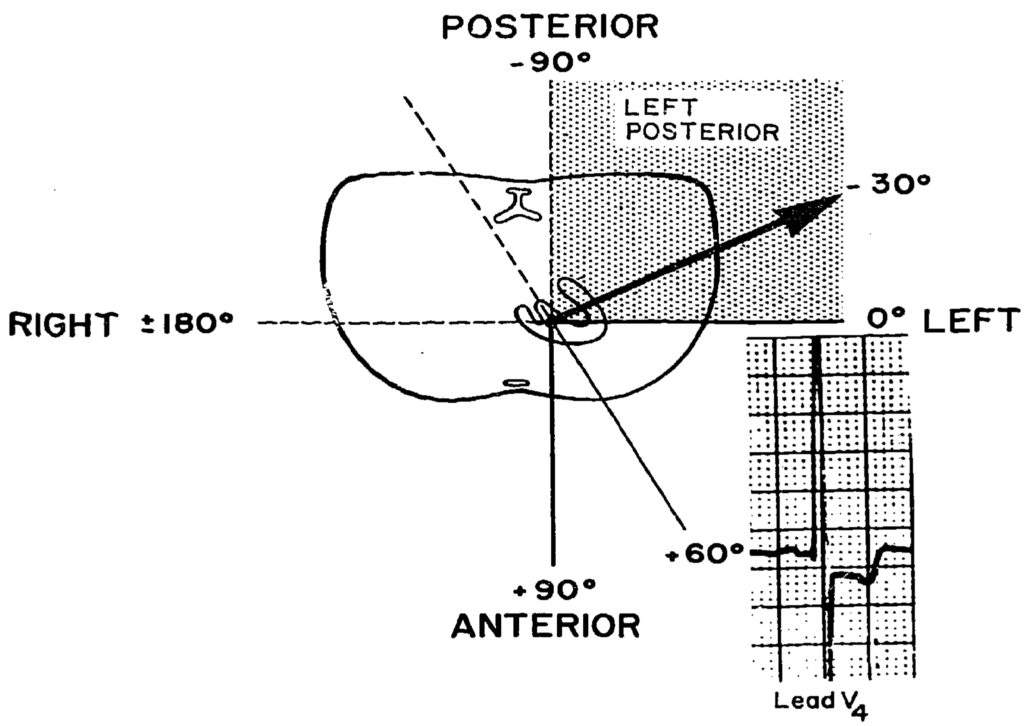


Return to page 118 and choose the correct answer.

From Page 113

Your answer, $-30°$, is correct.

The Perpendicular Rule of Spatial Analysis states the mean QRS vector is perpendicular to the axis of the lead with the equiphasic complex and in the preselected quadrant. Lead V_4 in this tracing presents an equiphasic QRS complex. The *mean horizontal QRS vector,* therefore, must lie perpendicular to the axis of lead V_4 in the preselected left and posterior quadrant at $-30°$.



Continue reading on page 117.

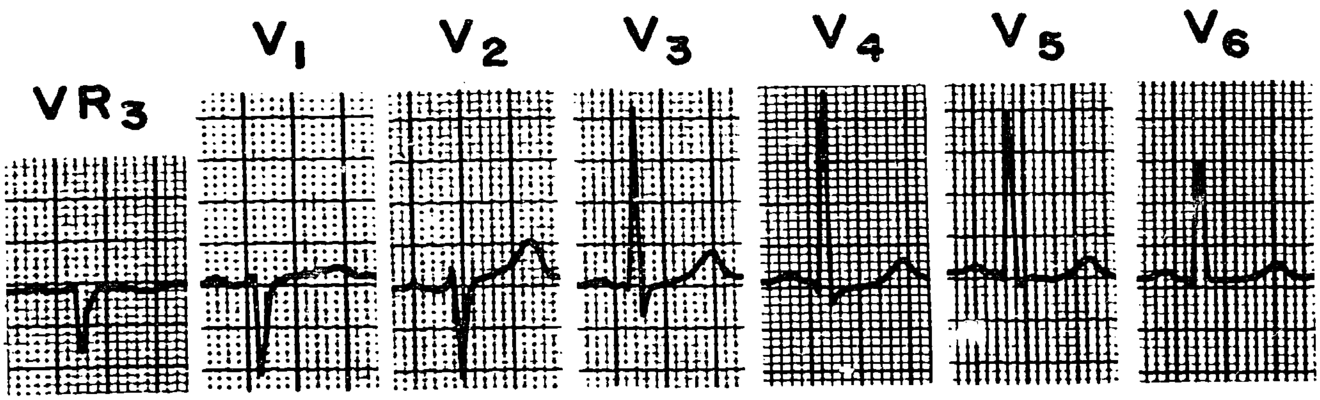
From Page 116

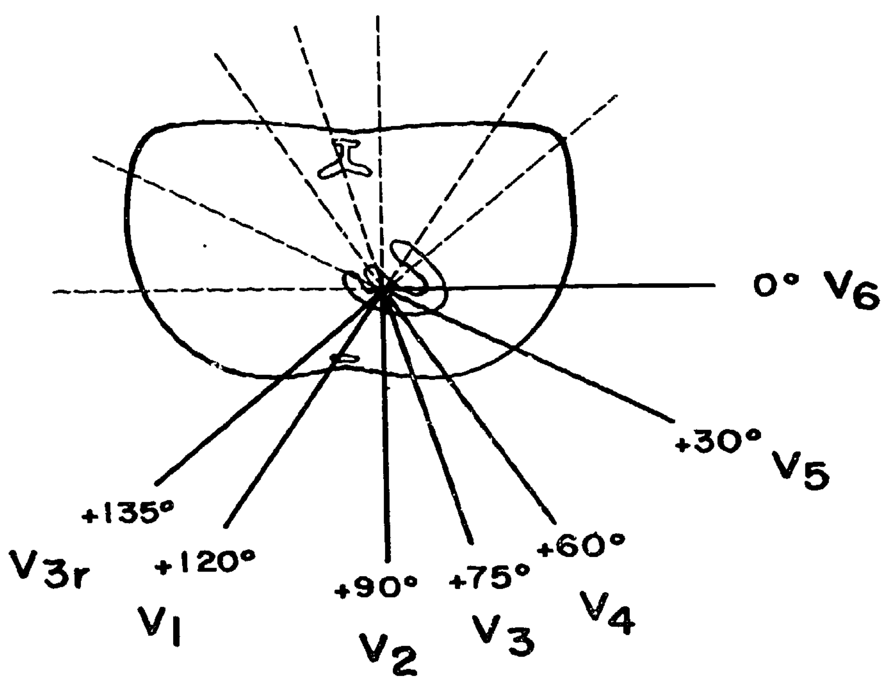
39

The net QRS forces along the left-right axis in the horizontal plane leads of this tracing are:

RIGHT page 119

LEFT page 122



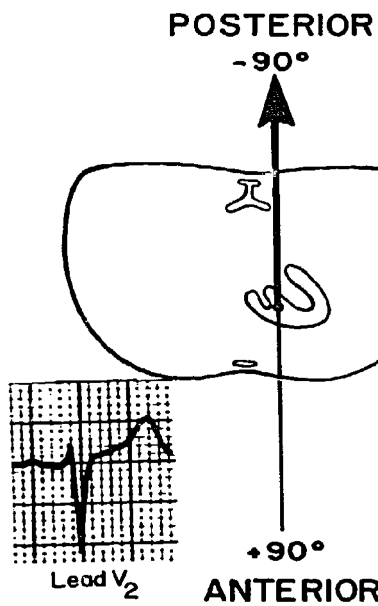


HORIZONTAL PLANE

From Page 122

Your answer, POSTERIOR, is correct.

The predominant QRS deflection in lead V_2 is *negative;* net QRS forces are *posterior.*



41

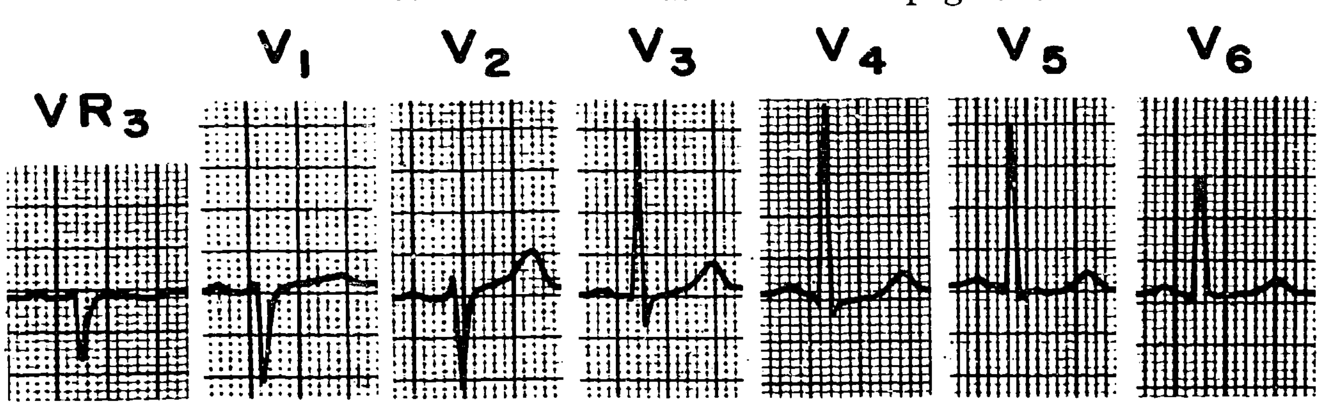
The mean horizontal QRS vector may be localized to a quadrant by combining the net QRS vectors from the left-right and anterior-posterior leads.

The mean horizontal QRS vector of this tracing is located:

LEFT AND POSTERIOR page 128

RIGHT AND POSTERIOR page 121

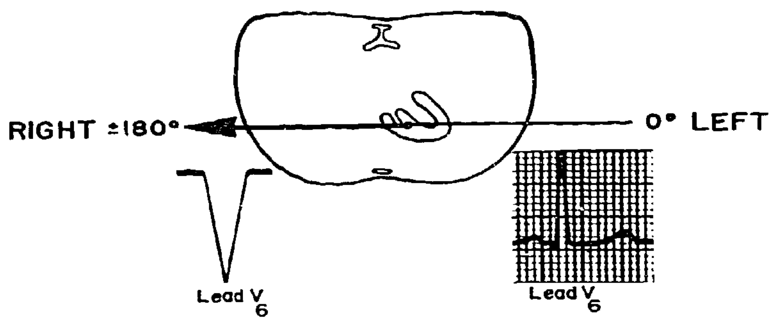
LEFT AND ANTERIOR page 115



From Page 117

Your answer, RIGHT, is incorrect.

Rightward QRS forces in the horizontal plane demand a predominant negative deflection in the left-right lead, V_6. The QRS complex in lead V_6 of this tracing is not predominantly negative.



Return to page 117 and choose the correct answer.

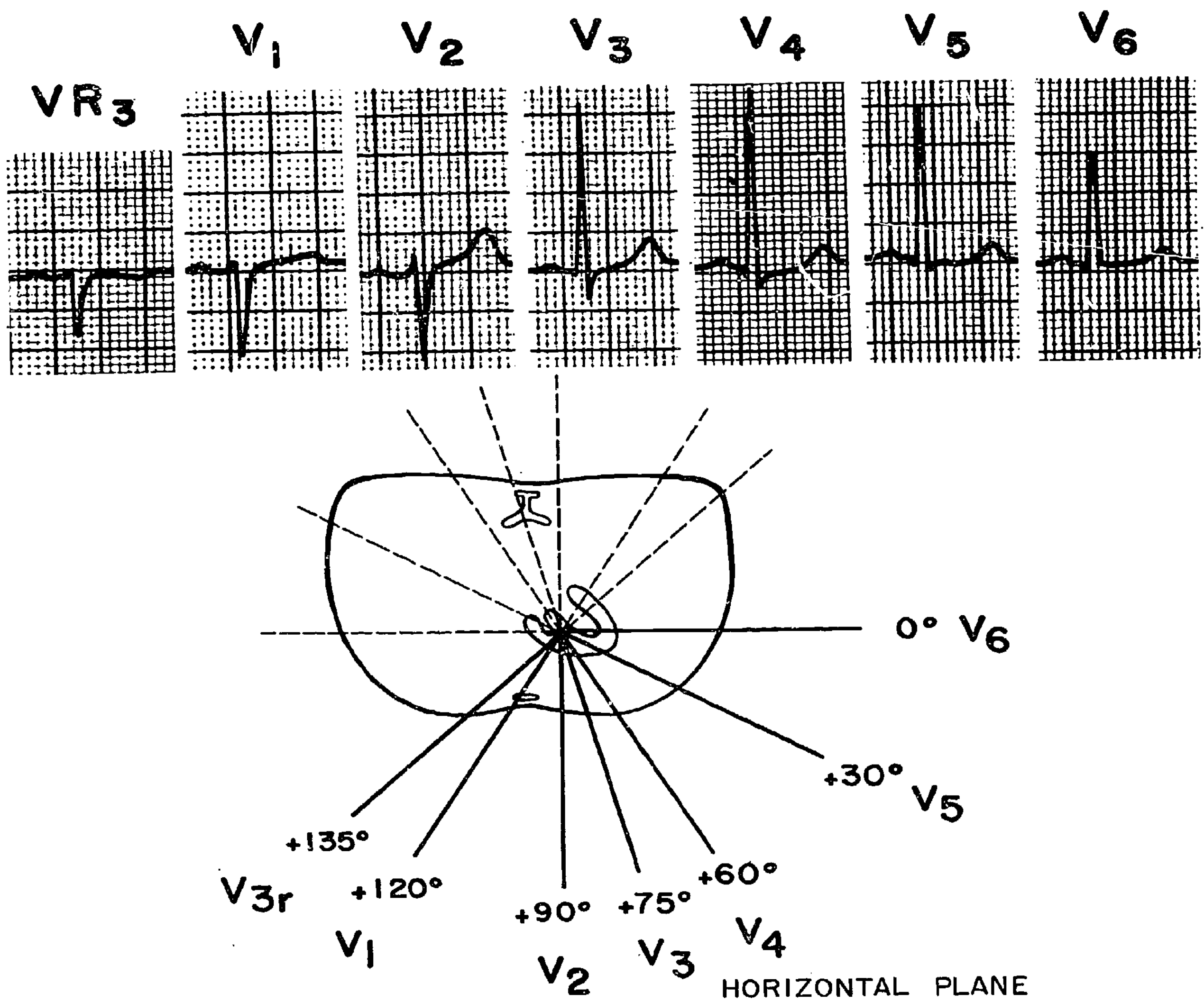
From Page 128

42

The mean horizontal QRS vector may be fixed in degrees by the Perpendicular Rule of Spatial Analysis. The mean vector lies perpendicular to the axis of the lead with the equiphasic complex and in the preselected quadrant. Occasionally tracings are obtained in which an equiphasic QRS complex is not observed. It is necessary, then, to approximate the location and axis of the lead in which the equiphasic complex would be anticipated.

The mean horizontal QRS vector in this tracing is located in the left and posterior quadrant at:

−10°	page 123
0°	page 125
−15°	page 127

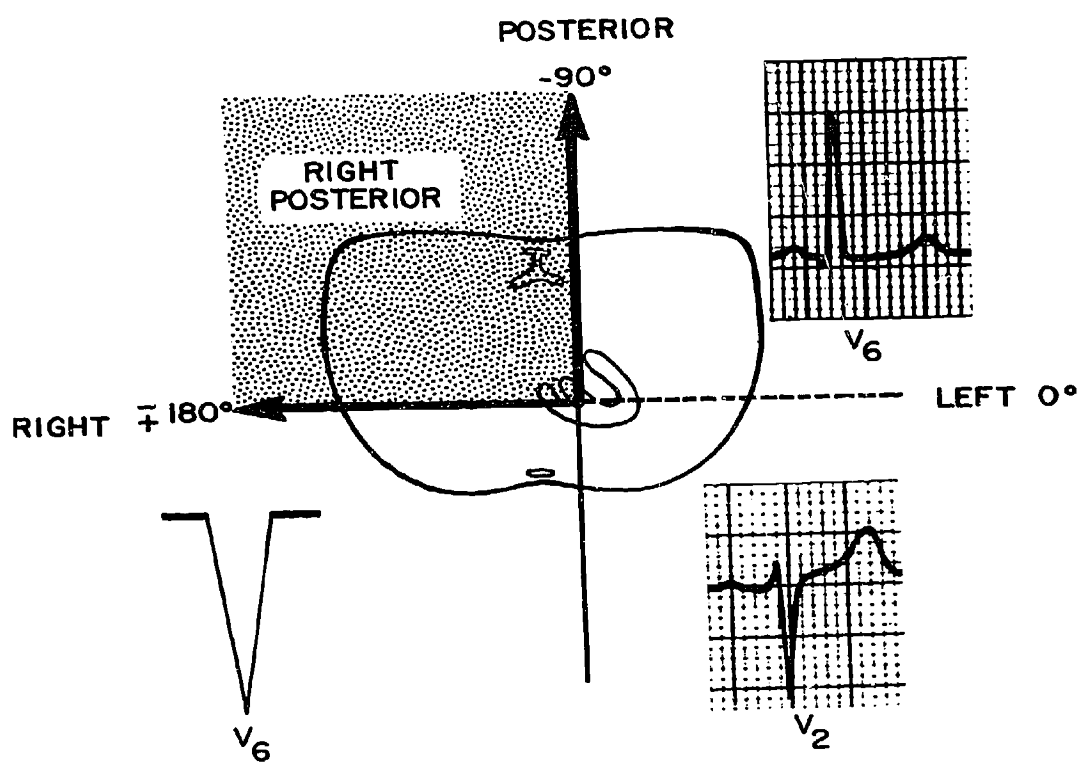


From Page 118

Your answer, RIGHT AND POSTERIOR, is incorrect.

A rightward mean horizontal QRS vector demands a predominant negative deflection in lead V_6; the QRS complex in lead V_6 in this tracing is not predominantly negative.

A posterior mean QRS vector requires a predominant negative QRS deflection in the anterior- posterior lead V_2; the QRS complex in V_2 of this tracing is predominantly negative; your answer is partially correct.

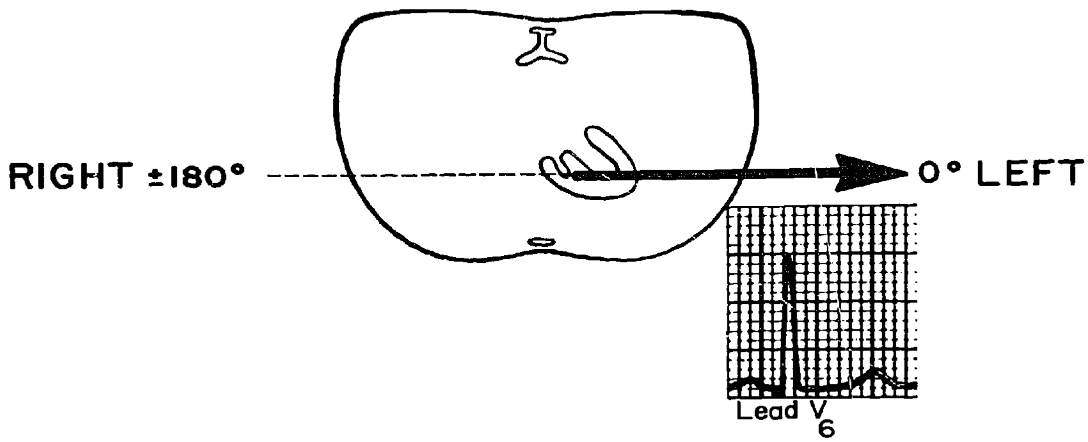


Return to page 118 and choose the correct answer.

From Page 117

Your answer, LEFT, is correct.

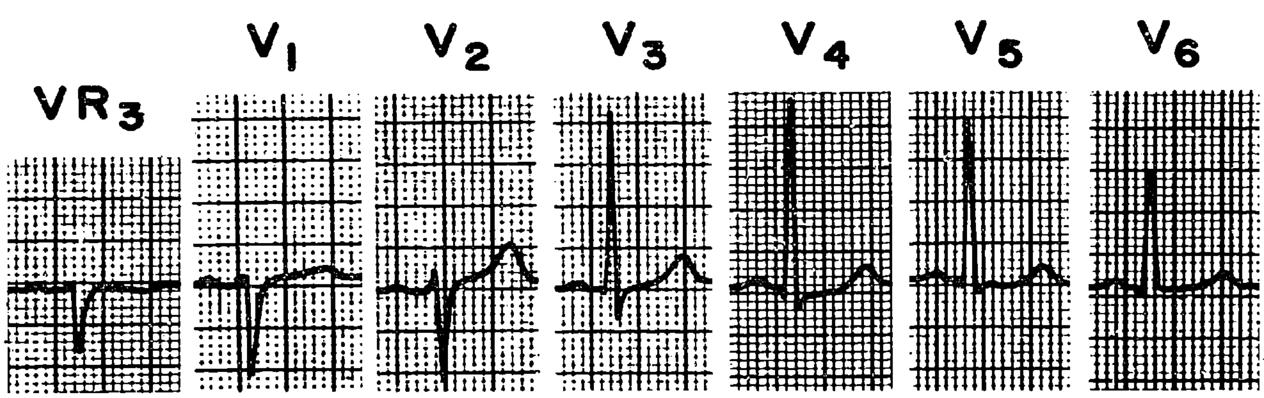
The predominant upright QRS deflection in lead V_6 indicates net QRS forces are left.



40

Net QRS forces along the anterior-posterior axis of this tracing are:

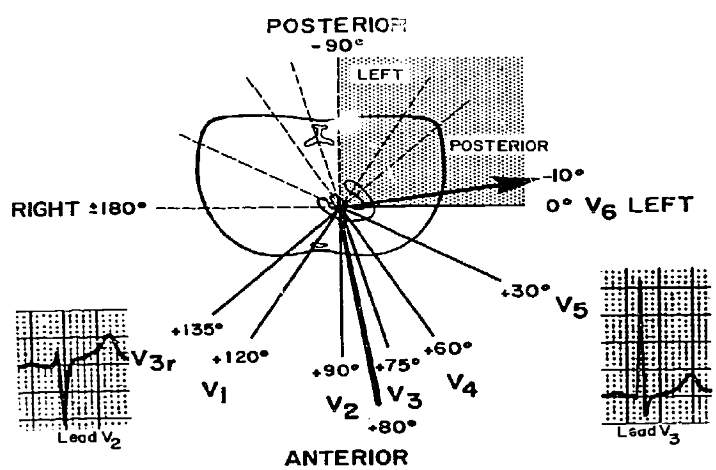
ANTERIOR	page 126
POSTERIOR	page 118



From Page 120

Your answer, $-10°$, is correct.

The Perpendicular Rule of Spatial Analysis states the mean QRS vector lies perpendicular to the axis of the lead with the equiphasic complex. An equiphasic QRS complex is not apparent in the chest leads. Since the QRS complex in lead V_2 is predominantly negative and the QRS complex in lead V_3 is predominantly positive, the lead with the equiphasic complex must be located between leads V_2 and V_3. The diagram indicates the positive axis of lead V_2 is at $+90°$ and the positive axis of lead V_3 is at $+75°$; the positive axis of a lead lying between leads V_2 and V_3, therefore, must approximate $+80°$. The mean horizontal QRS vector, then, must lie in the preselected *left and posterior quadrant*, perpendicular to the $+80°$ axis, at $-10°$.



Continue reading on page 129.

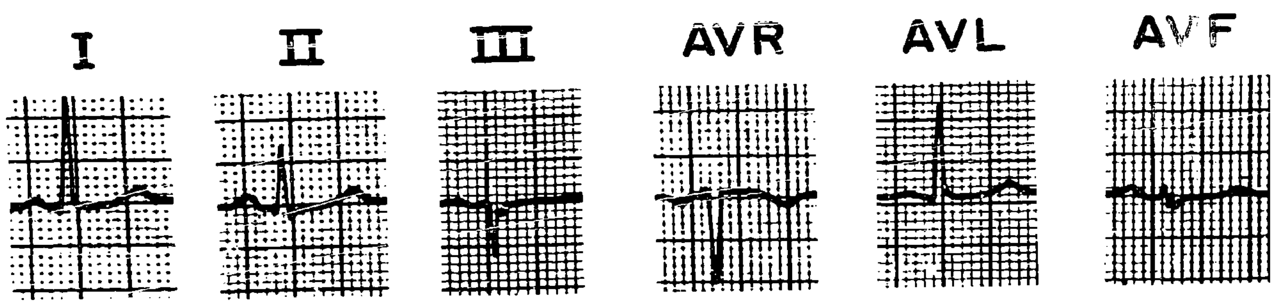
From Page 133

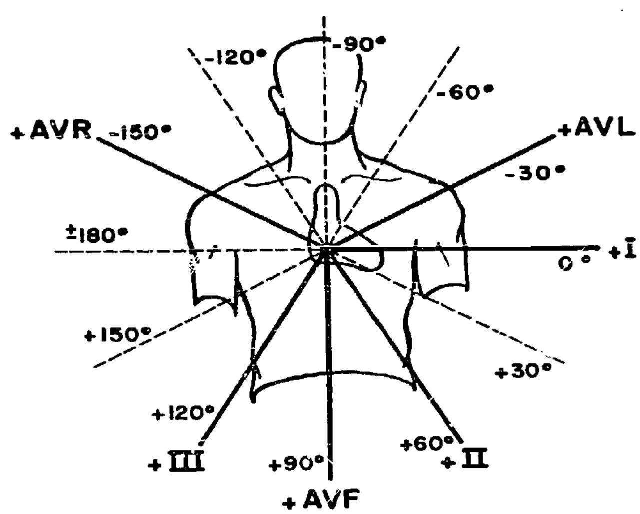
44

The Perpendicular Rule of Spatial Analysis is used to locate the mean T vector in degrees.

The mean frontal T vector in this electrocardiogram is:

−150°	page 130
+60°	page 134
+30°	page 137
0°	page 132



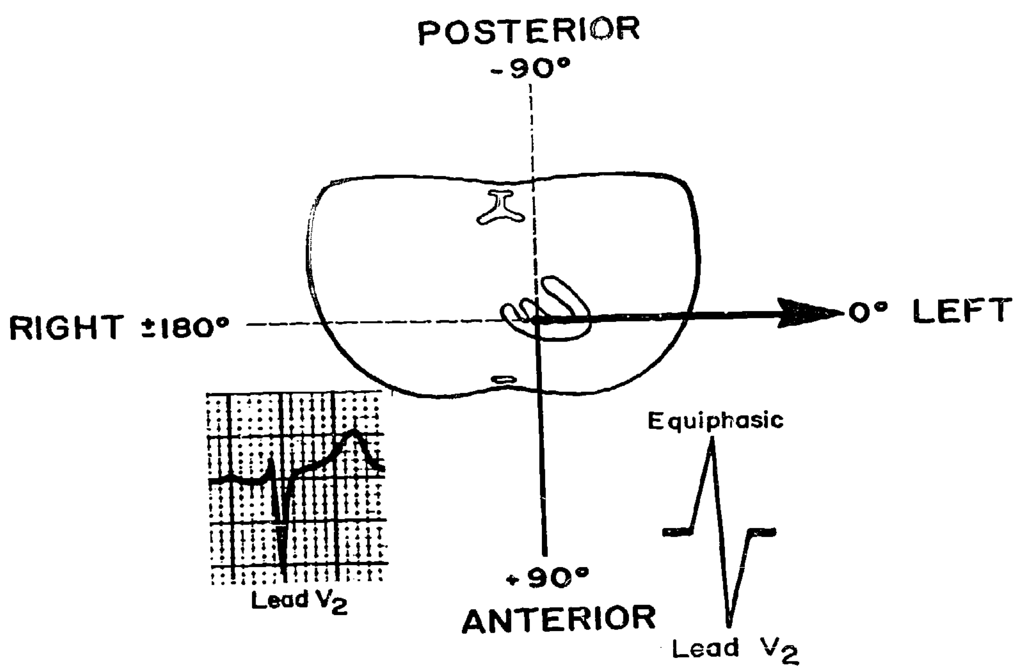


FRONTAL PLANE

From Page 120

Your answer, 0°, is incorrect.

The Perpendicular Rule of Spatial Analysis states the mean QRS vector lies perpendicular to the axis of the lead with the equiphasic complex. To achieve a mean horizontal QRS vector of 0°, the equiphasic complex must be located in lead V_2. Lead V_2 does not present an equiphasic complex.

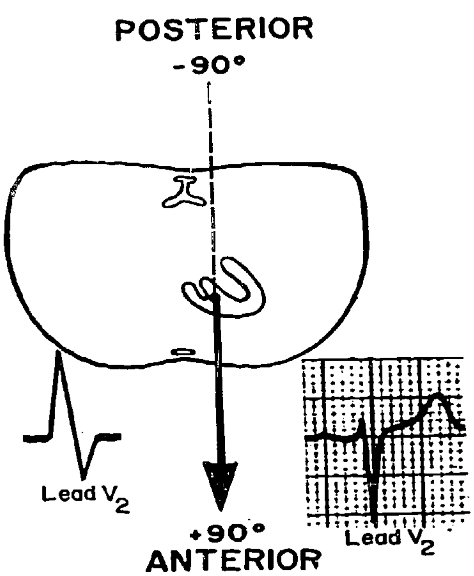


Return to page 120 and choose the correct answer.

From Page 122

Your answer, ANTERIOR, is incorrect.

Net anterior QRS forces demand a predominant upright deflection in lead V_2. The QRS complex in lead V_2 of this tracing is not predominantly upright.

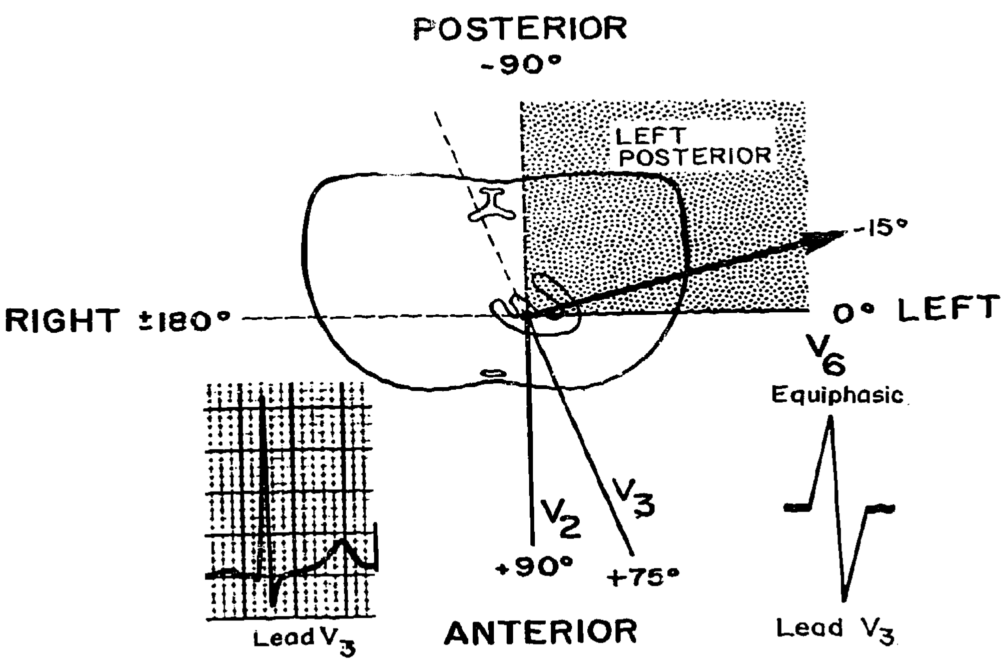


Return to page 122 and choose the correct answer.

From Page 120

Your answer, −15°, is incorrect.

The Perpendicular Rule of Spatial Analysis states the mean QRS vector lies perpendicular to the axis of the lead with the equiphasic complex. To achieve a mean horizontal QRS vector at −15°, the equiphasic complex must be located in lead V_3. Lead V_3 of this tracing does not present an equiphasic complex.

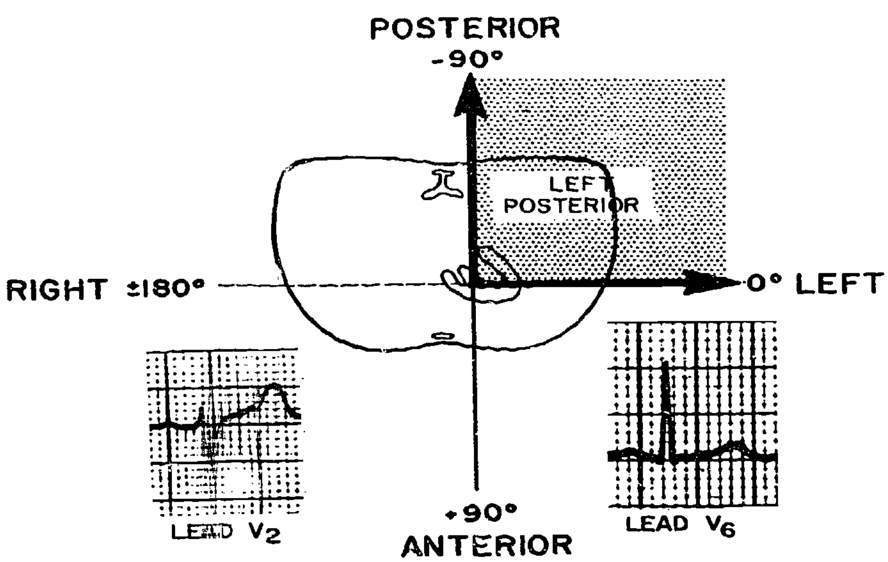


Return to page 120 and choose the correct answer.

From Page 118

Your answer, LEFT AND POSTERIOR, is correct.

The large upright deflection in lead V_6 indicates net QRS forces are left; the predominant negative deflection in lead V_2 indicates the mean horizontal QRS vector is *posterior*. Combining the net vectors along the anterior-posterior and left-right axes locates the mean horizontal QRS vector in the *left and posterior quadrant.*



Continue reading on page 120.

From Page 123

43

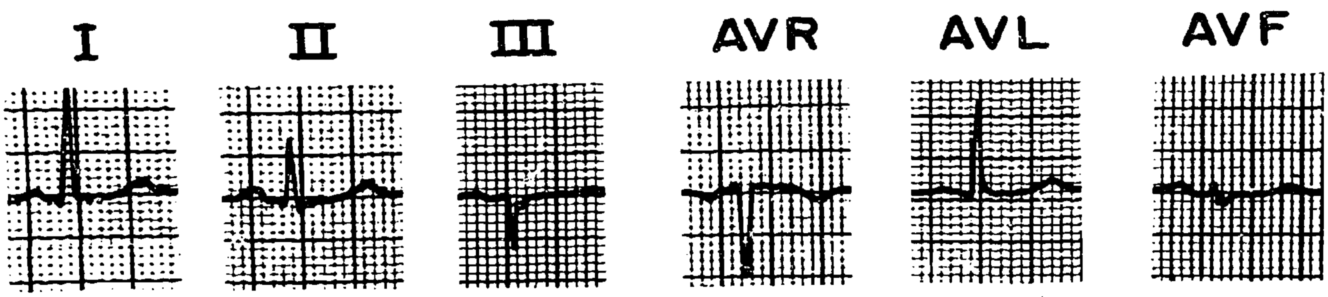
The mean T vector may be determined similar to the mean QRS vector by the Quadrant and Perpendicular Rules of Spatial Analysis.

The mean frontal T vector from the frontal plane leads is:

RIGHT AND INFERIOR page 131

LEFT AND INFERIOR page 133

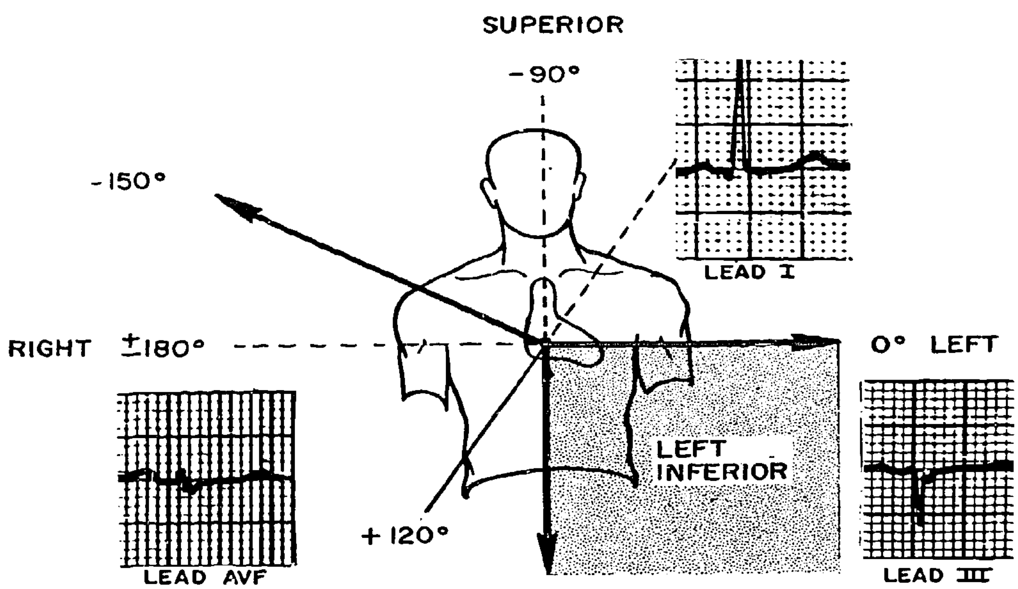
LEFT AND SUPERIOR page 136



From Page 124

Your answer, $-150°$, is incorrect.

The Perpendicular Rule locates the mean T vector perpendicular to the axis of the lead with the equiphasic or flat T wave. A flat T wave is observed in lead III. A mean T vector at $-150°$ is perpendicular to the axis of lead III but *does not* lie in the preselected left and inferior quadrant.

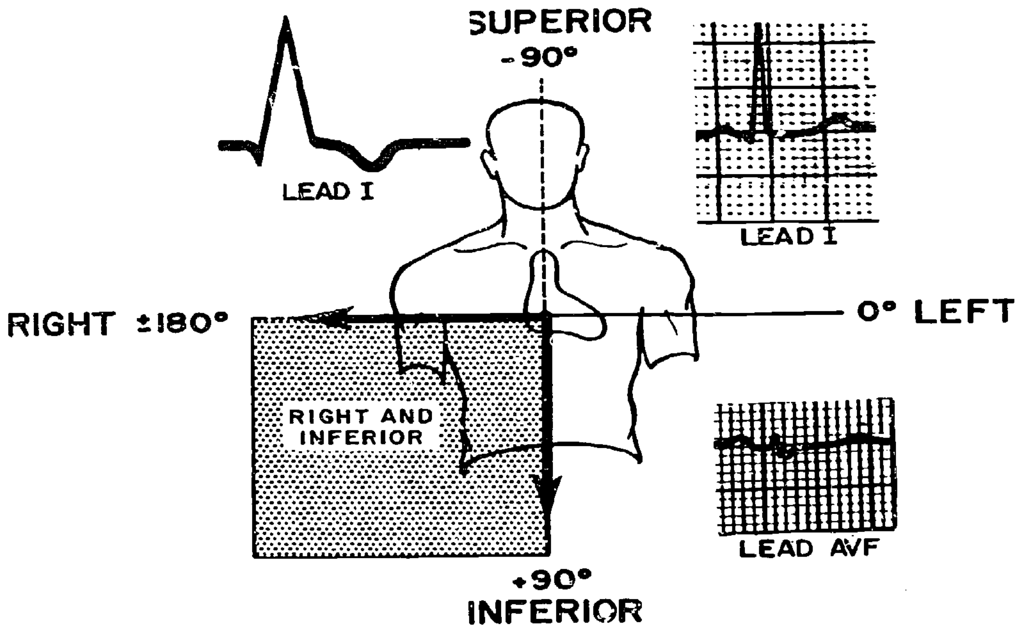


Return to page 124 and choose the correct answer.

From Page 129

Your answer, RIGHT AND INFERIOR, is incorrect.

The upright T deflection in lead AVF indicates the mean T vector is *inferior;* this portion of your answer is correct. A *rightward* mean T vector, however, demands a predominant negative T deflection in lead I. A negative T deflection is not noted in lead I of this tracing.

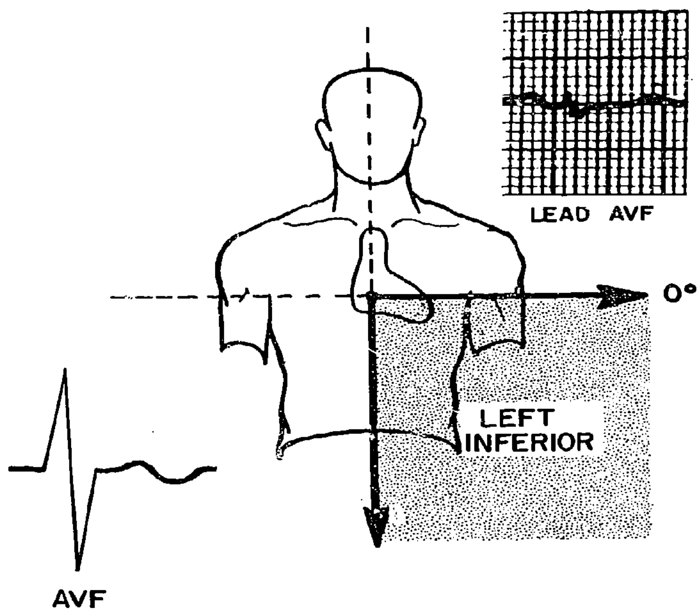


Return to page 129 and choose the correct answer.

From Page 124

Your answer, 0°, is incorrect.

A mean frontal *T vector* at 0° by the Perpendicular Rule demands an equiphasic or flat *T wave* in lead AVF. The T wave in lead AVF in this tracing is upright.

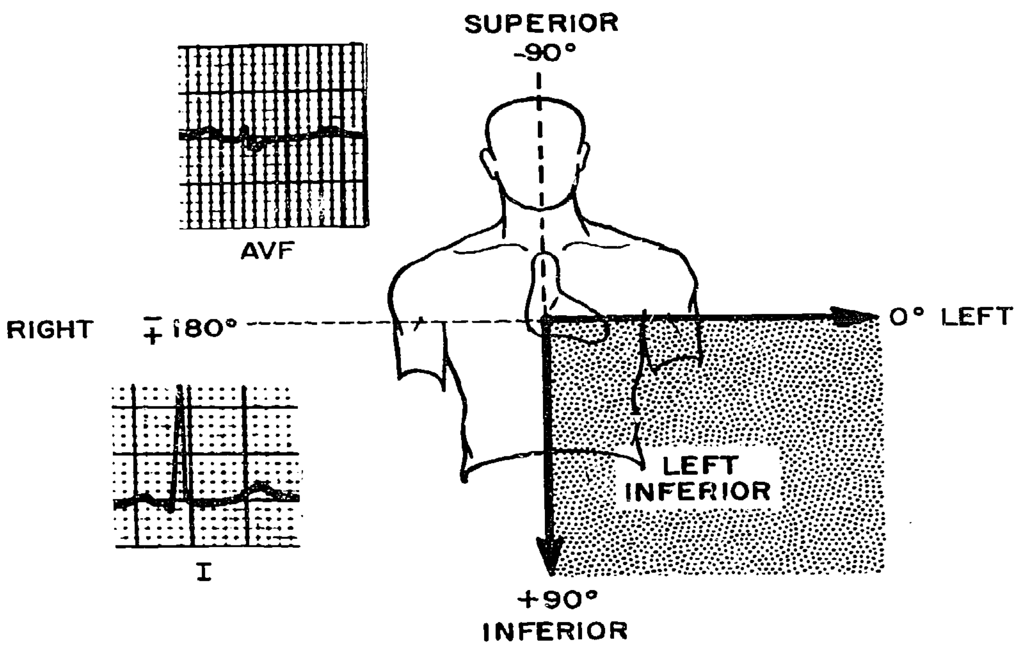


Return to page 124 and choose the correct answer.

From Page 129

Your answer, LEFT AND INFERIOR, is correct.

The predominant upright T deflections in leads I and AVF indicate the mean T vector lies *left and inferior.*

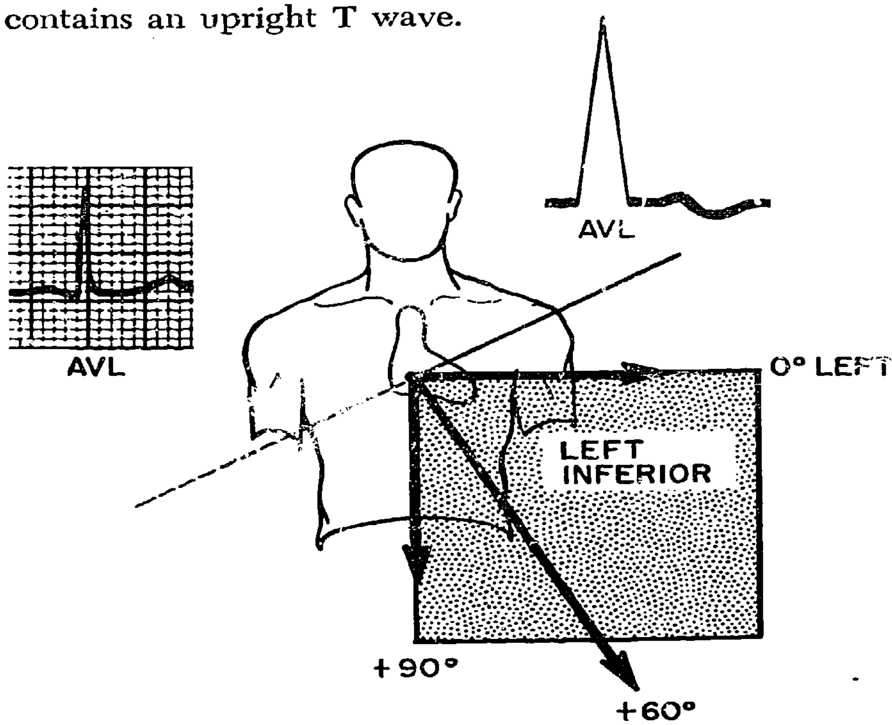


Continue reading on page 124.

From Page 124

Your answer, +60°, is incorrect.

The Quadrant Rule has localized the mean frontal T vector left and inferior. A mean frontal T vector at +60° by the Perpendicular Rule demands an equiphasic or flat T wave in lead AVL. Lead AVL in this tracing contains an upright T wave.



Return to page 124 and choose the correct answer.

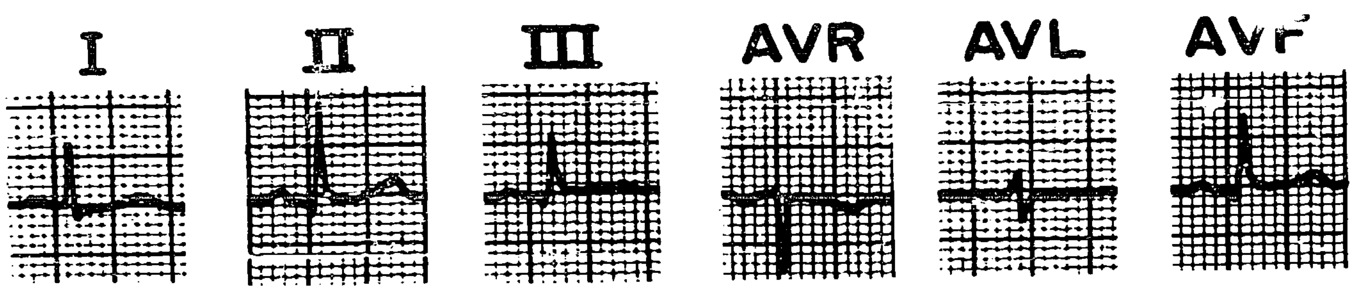
From Page 145

46

The mean P vector may be determined in a manner similar to the mean QRS and T vectors.

The mean frontal *P vector* in the frontal plane leads below is:

LEFT AND INFERIOR	page 139
RIGHT AND INFERIOR	page 140
LEFT AND SUPERIOR	page 142

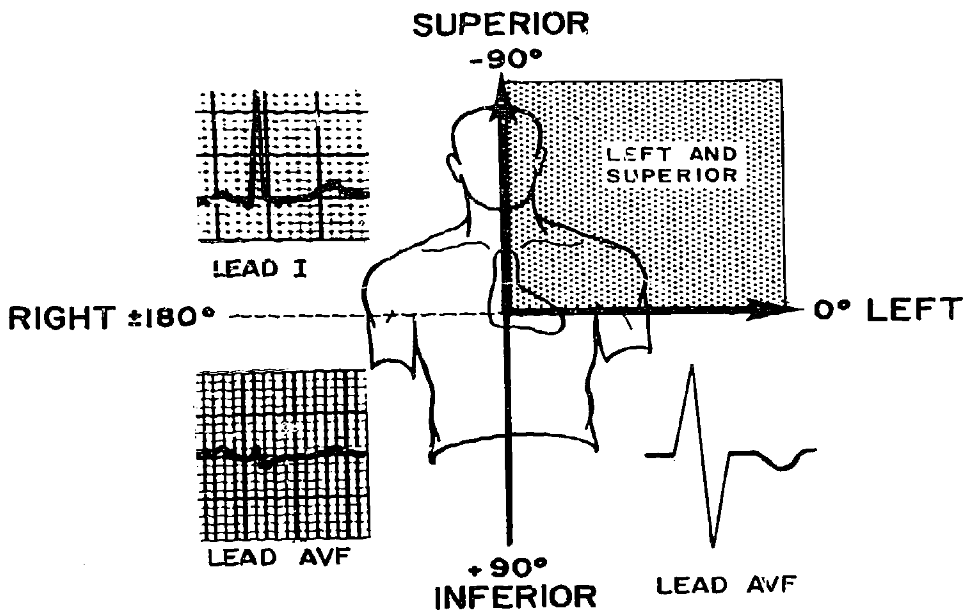


From Page 129

Your answer, LEFT AND SUPERIOR, is incorrect.

The upright T deflection in lead I indicates the mean T vector is *left*; this portion of your answer is correct.

A *superior* mean T vector demands a predominant negative T deflection in lead AVF. A negative T deflection, however, is not noted in lead AVF.

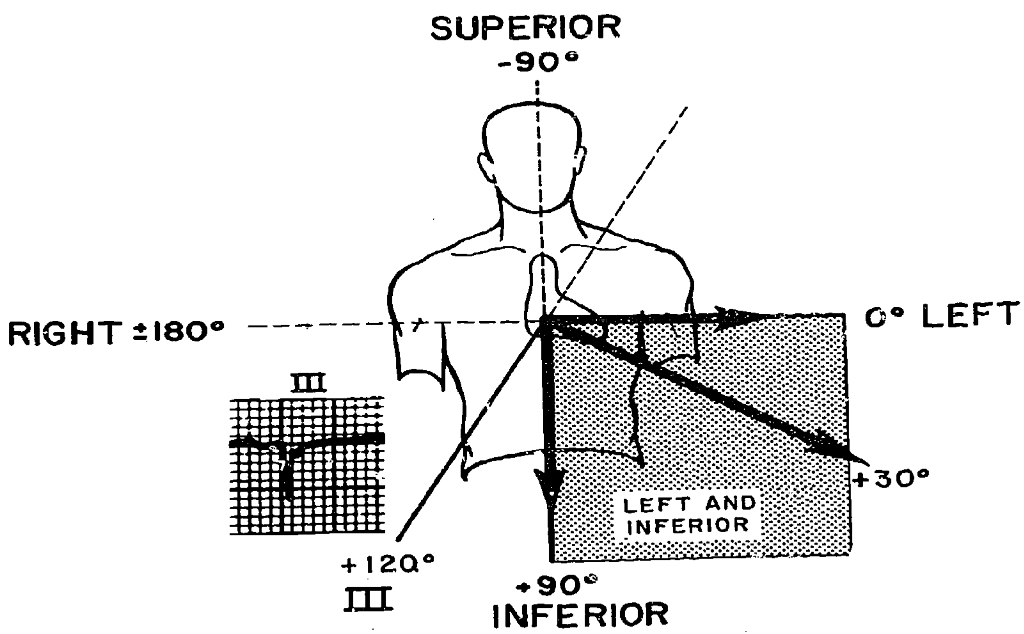


Return to page 129 and choose the correct answer.

From Page 124

Your answer, +30°, is correct.

The Quadrant Rule has localized the mean frontal T vector in the left and inferior quadrant. The T wave in lead III is flat with a net area of zero and, hence, is an equiphasic T wave. The mean T vector is perpendicular to the axis of lead III in the preselected left and inferior quadrant at +30°.



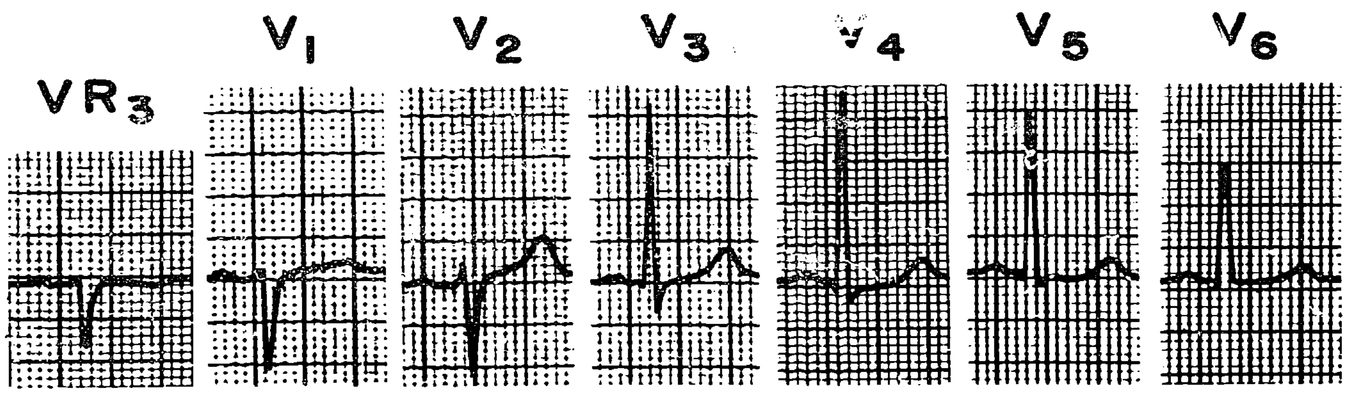
Continue reading on page 138.

From Page 137

45

The mean horizontal T vector in the horizontal plane leads below is:

LEFT AND POSTERIOR	page 147
RIGHT AND ANTERIOR	page 143
LEFT AND ANTERIOR	page 145

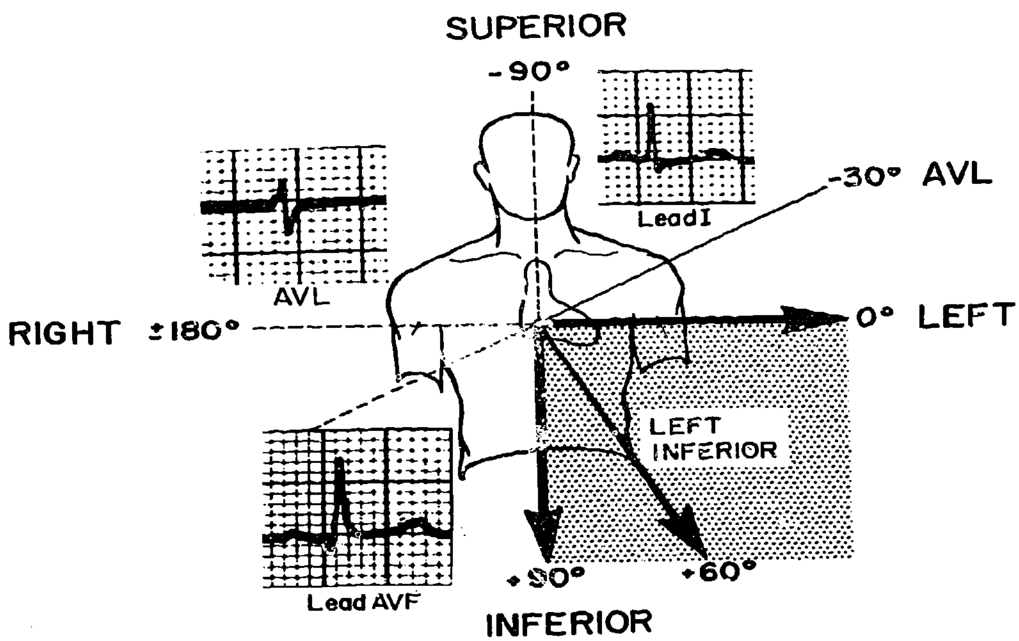


From Page 135

Your answer, LEFT AND INFERIOR, is correct.

The upright P deflection in lead I indicates net atrial forces are *left;* the upright P deflection in lead AVF indicates net atrial forces are *inferior*. The Quadrant Rule of Spatial Analysis, therefore, places the mean frontal P vector in the *left and inferior quadrant*.

Locating the P vector precisely in degrees often is difficult because atrial voltages are small. With small atrial voltages it is difficult to locate the lead with the equiphasic or flat P deflection. This tracing presents an equiphasic or flat P wave in lead AVL. The mean frontal P vector, therefore, lies perpendicular to the axis of lead AVL in the preselected *left and inferior quadrant, at +60°*.



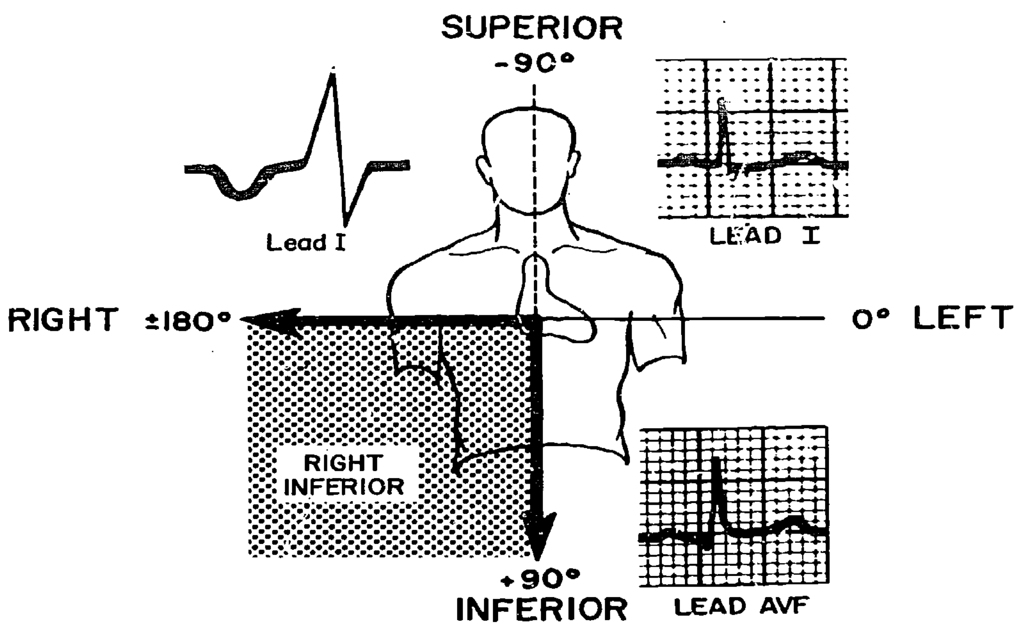
Continue reading on page 144.

From Page 135

Your answer, RIGHT AND INFERIOR, is incorrect.

The upright P wave in lead AVF indicates the mean P vector is inferior; this portion of your answer is correct.

A rightward mean P vector, however, demands a predominant negative P deflection in lead I. A negative P deflection is not noted in lead I of this tracing.



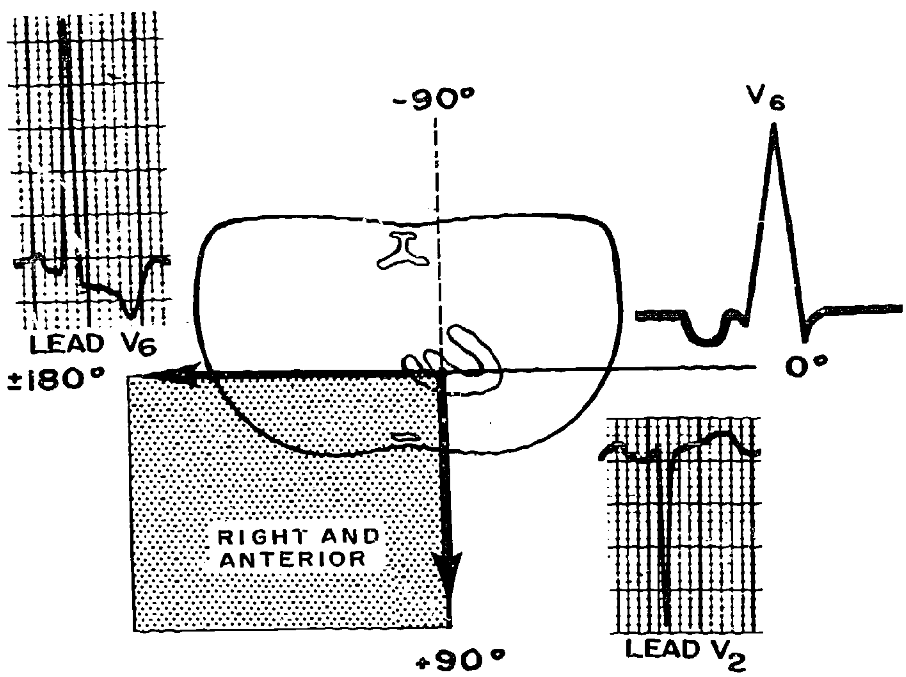
Return to page 135 and choose the correct answer.

From Page 144

Your answer, RIGHT AND ANTERIOR, is incorrect.

The upright P deflection in lead V_2 indicates the mean P vector lies *anterior;* this portion is correct.

A rightward mean P vector demands a negative P deflection in lead V_6. A negative P deflection is not present in lead V_6 of this tracing.



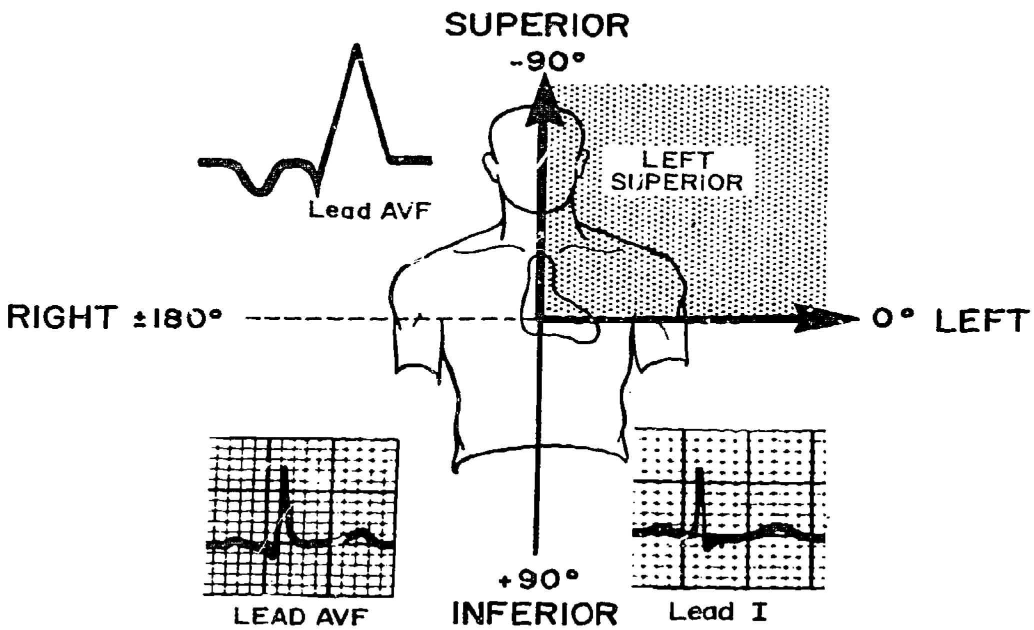
Return to page 144 and choose the correct answer.

From Page 135

Your answer, LEFT AND SUPERIOR, is incorrect.

The predominant upright P deflection in lead I indicates the mean P vector is *left;* this portion of your answer is correct.

A superior mean P vector, however, demands a predominant negative P deflection in lead AVF. Lead AVF of this tracing does not display a predominant negative P deflection.



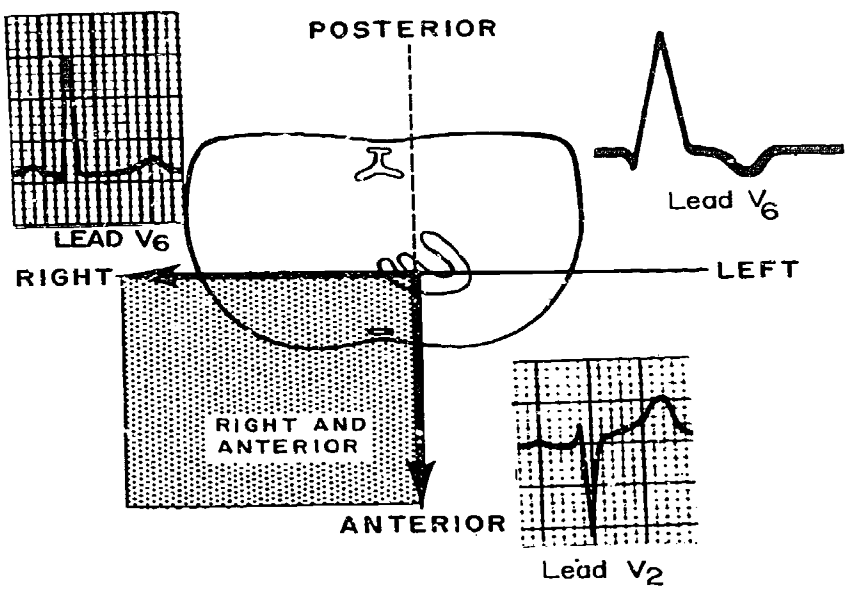
Return to page 135 and choose the correct answer.

From Page 138

Your answer, RIGHT AND ANTERIOR, is incorrect.

The upright T deflection in lead V_2 indicates the mean T vector is *anterior;* this portion of your answer is correct.

A *rightward* mean T vector, however, demands a predominant negative T deflection in lead V_6; a negative T deflection is not noted in lead V_6 of this tracing.



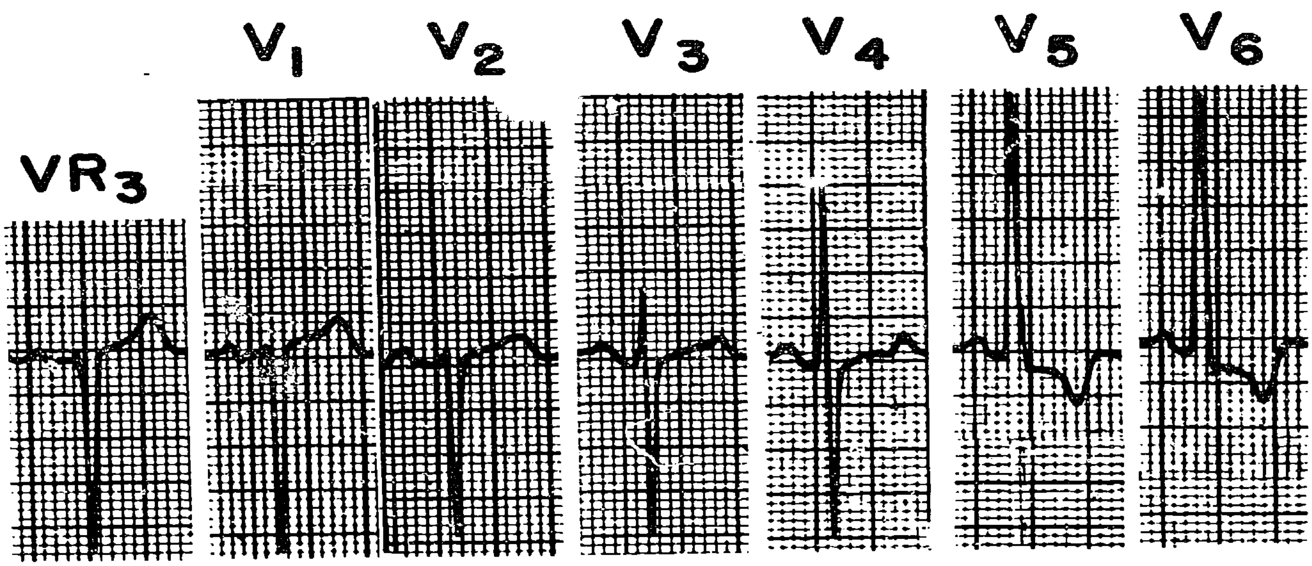
Return to page 138 and choose the correct answer.

From Page 139

47

The mean horizontal P vector in the horizontal plane leads below is:

RIGHT AND ANTERIOR	page 141
LEFT AND POSTERIOR	page 146
LEFT AND ANTERIOR	page 148

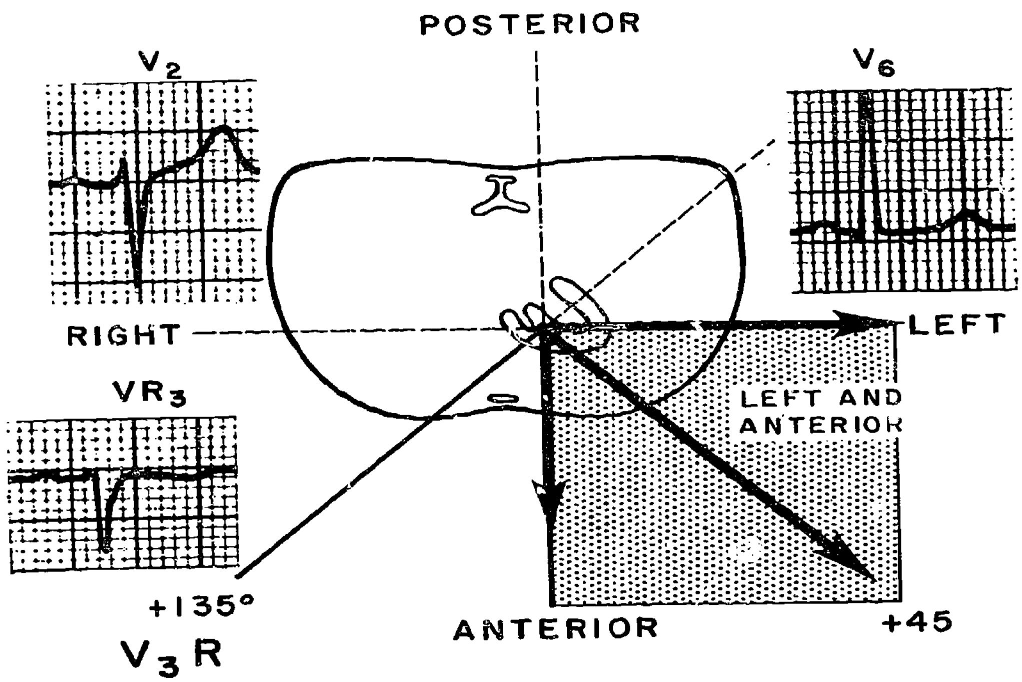


From Page 138

Your answer, LEFT AND ANTERIOR, is correct.

The upright T deflection in lead V_2 indicates the mean T vector is *anterior;* the upright T deflection in lead V_6 indicates the mean T vector is *left*. The mean horizontal T vector, therefore, is left and anterior.

Because T forces are often small, for the Perpendicular Rule, it is adequate to select the lead with the most nearly equiphasic or flat T wave. The T wave most nearly equiphasic is in lead V_3R; the mean horizontal T vector may be fixed *left and anterior* at approximately $+45°$.



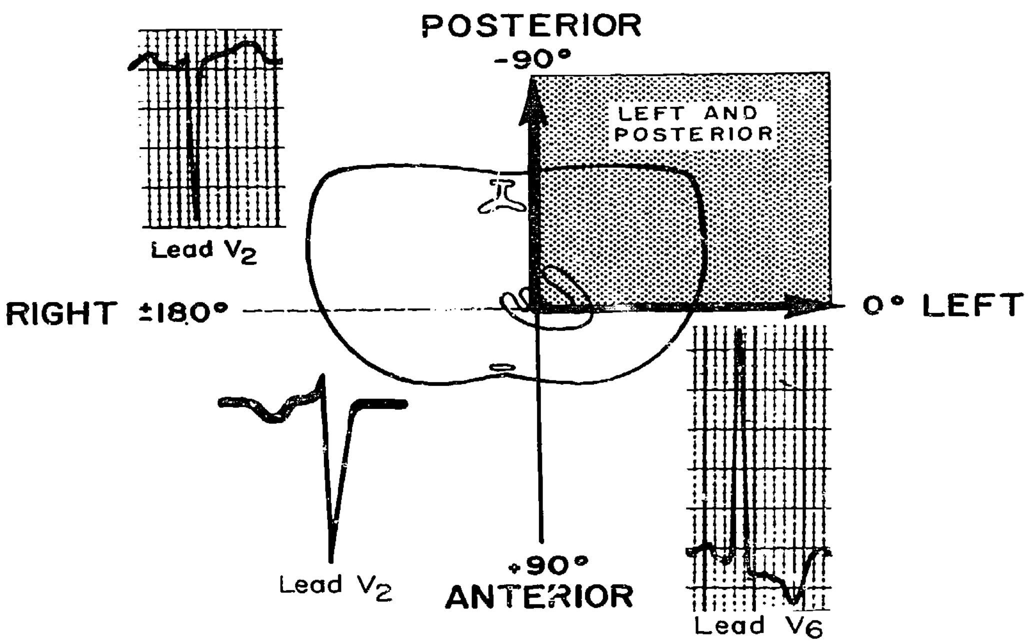
Continue reading on page 135.

From Page 144

Your answer, LEFT AND POSTERIOR, is incorrect.

The upright P deflection in lead V_6 indicates mean P forces are *left*; this portion of your answer is correct.

Posterior P forces, however, demand a negative P deflection in lead V_2; a predominant negative P deflection is not noted in lead V_2 of this tracing.



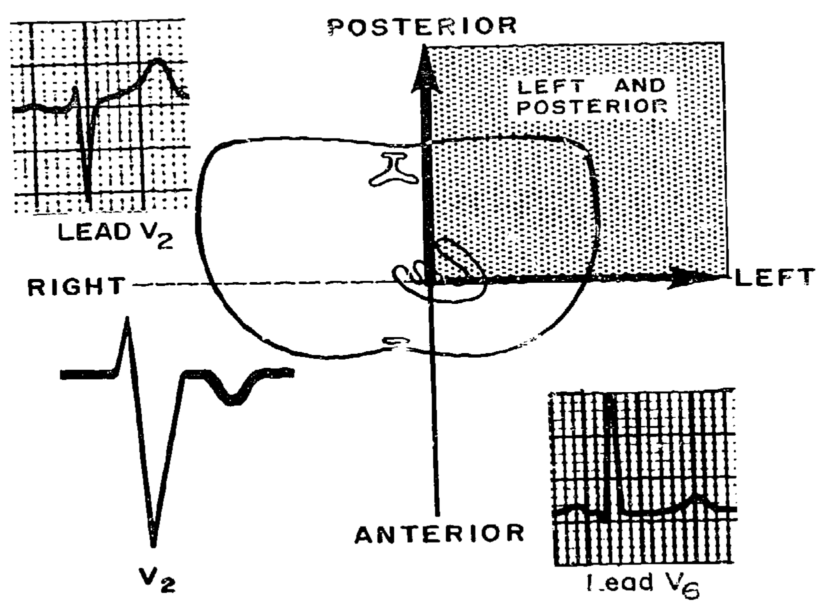
Return to page 144 and choose the correct answer.

From Page 138

Your answer, LEFT AND POSTERIOR, is incorrect.

The upright T deflection in lead V_6 indicates the mean T vector is left; this portion of your answer is correct.

A posterior mean T vector, however, demands a predominant negative T deflection in lead V_2; a negative T deflection is not noted in lead V_2 of this tracing.

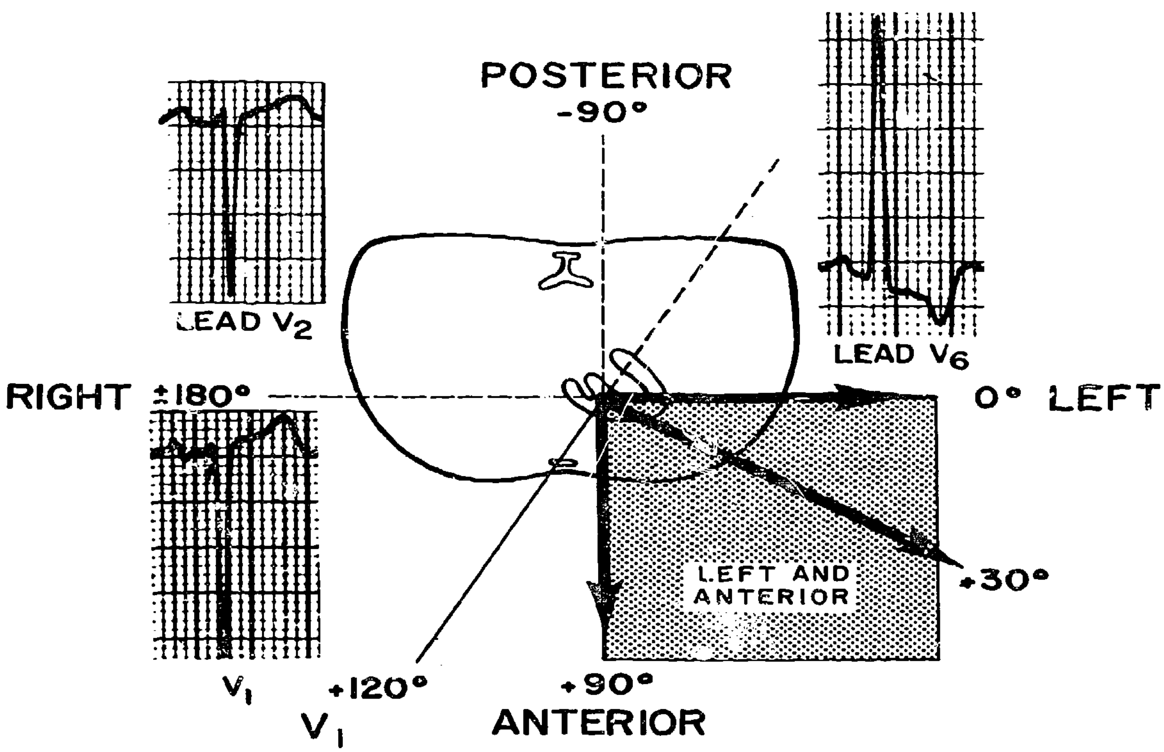


Return to page 138 and choose the correct answer.

From Page 144

Your answer, LEFT AND ANTERIOR, is correct.

The predominant upright P deflection in leads V_2 and V_6 locate the mean horizontal P vector *left and anterior*. The equiphasic P deflection in lead V_1 fixes the mean horizontal P vector *left and anterior at +30°*.



Continue reading on page 149.

SUMMARY

This chapter, The Introduction to the Method of Spatial Analysis, has emphasized the following principles:

1. An upright deflection in any lead represents forces moving toward the positive electrode of that lead.

2. The three spatial axes of the body may be represented best by—

   a. Leads I or V_6 for the left-right axis,

   b. Lead AVF for the superior-inferior axis, and

   c. Leads V_1 or V_2 for the anterior-posterior axis.

An upright deflection, therefore, represents leftward forces in leads I or V_6, inferior forces in lead AVF, and anterior forces in leads V_1 or V_2.

3. Mean vectors may be localized by the *Quadrant and Perpendicular Rules of Spatial Analysis*. The mean frontal vector may be localized to a quadrant by combining the net directions of forces in the left-right and superior-inferior leads; the mean horizontal vector may be localized similarly utilizing the left-right and anterior-posterior leads.

4. The mean vector may be fixed more precisely in degrees by the *Perpendicular Rule of Spatial Analysis*. This rule states the mean vector lies perpendicular to the axis of the lead with the equiphasic complex and in the preselected quadrant.

5. You now should be able to determine the mean P, QRS, and T vectors of any electrocardiogram with this Method of Spatial Analysis.

END

APPENDIX - B

Chapter I

Introduction to the Method of Spatial Analysis

Spatial Analysis of the Electrocardiogram*

This text is designed to teach spatial analysis of any electrocardiogram. It was developed and prepared at the University of Southern California School of Medicine, Department of Electrocardiography, Los Angeles, California, by:

Irwin Hoffman, M.D.

Julien H. Isaacs, M.D.

James V. Dooley, M.D.

Phil R. Manning, M.D.

and

Donald A. Dennis, M.A.

Programming Consultant

Preface

A Technique of Spatial Analysis of any electrocardiogram will be presented in a step by step fashion utilizing a narrative format. Each step will present an introductory statement and a specific illustration based on this information. Important principals or facts may be reviewed more than once in a different manner for reinforcement. No attempt will be made to cover the entire field of electrocardiography.

Table of Contents

Table of Contents

The normal heart is activated region by region. The interventricular septum is depolarized prior to any other region of the ventricles. The activation wavefront passes progressively from the interventricular septum to the anterior wall; the anterior wall completes activation prior to the lateral wall; the lateral wall completes activation prior to the posterior wall. The inferior regions of both ventricles are activated prior to the superior or basilar regions. The normal activation wavefront, therefore, has a specific directional sequence in space.

A pathophysiologic change in the heart, hypertrophy, block, or infarction, produces abnormal changes in the electrocardiogram by altering this sequence of regional activation or by changing the electrical field produced by an involved region of the heart.

The standard electrocardiogram reflects these changes in the activation sequence of the heart. The method of analysis in this text will develop a technique of spatial analysis for any electrocardiogram. Future chapters in this text will permit the interpreter to determine the sequence of regional activation in the heart both in normal and disease states and the effects of disease on important regional vectors. This technique we have called *Spatial Analysis*.

Prerequisites

The following information is basic to the understanding and completion of the material included in the forthcoming text:

I. Elementary knowledge of anatomy of the heart.

II. Ability to identify the various electrocardiographic complexes: P, QRS, and T.

III. An understanding of the terms: left-right, superior-inferior, and anterior-posterior in relation to the heart as it is located in the chest.

Course Goal

At the completion of this course you will be able to determine mean P, QRS, and T vectors in space utilizing the method of spatial analysis.

Chapter I

INTRODUCTION TO THE METHOD OF SPATIAL ANALYSIS

SECTION I

ORIENTATION OF FRONTAL PLANE LEADS

1. BASIC CONCEPTS

An upright deflection or R Wave in any lead of the electrocardiogram represents QRS forces moving toward the positive electrode of that lead (Figure 1). A negative deflection, a Q or an S wave, in any lead represents QRS forces moving away from the positive electrode, that is, toward the negative electrode (Figure 2).

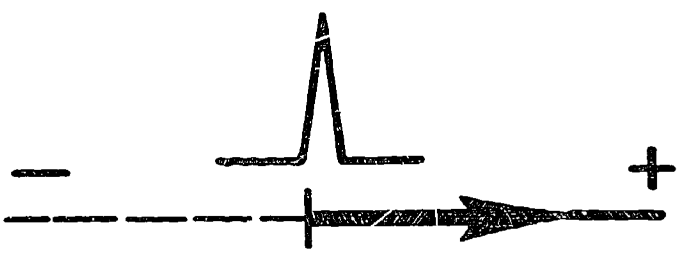


Figure 1

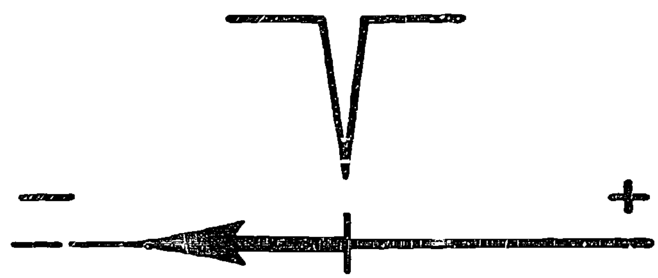


Figure 2

2. BIPOLAR LEADS

2.1 *Lead I*

Lead I is a bipolar lead with its positive electrode located on the left arm and its negative electrode located on the right arm (Figure 3).

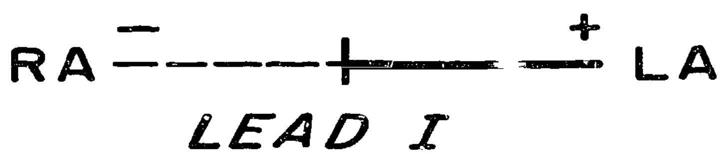


Figure 3

An upright deflection, an R wave, in lead I therefore must represent QRS forces moving toward the positive electrode and hence toward the left arm (Figure 4).

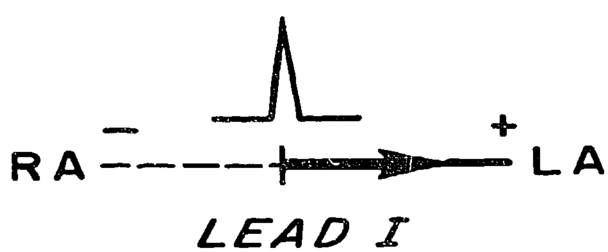


Figure 4

A negative deflection, a Q or an S wave, in lead I represents QRS forces moving away from the positive electrode and hence toward the right arm (Figure 5).

Figure 5

These assumptions are *fundamental to the understanding of the Method of Spatial Analysis.*

2.2 *Lead II*

Lead II is a bipolar lead with its positive electrode located on the left leg and its negative electrode on the right arm (Figure 6).

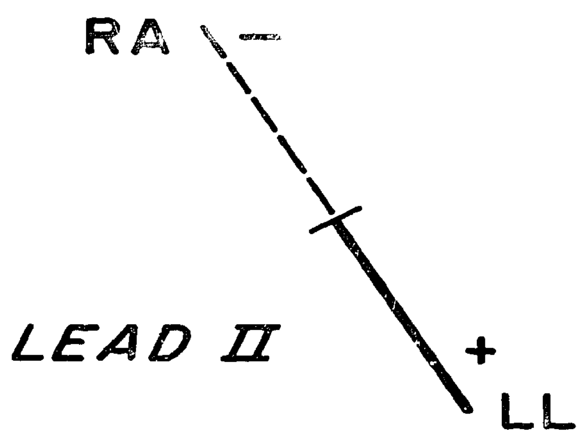


Figure 6

An upright deflection, an R wave, in lead II must represent QRS forces moving toward the positive electrode of this lead and hence toward the left leg (Figure 7).

A negative deflection represents QRS forces moving toward the negative electrode, i.e., toward the right arm (Figure 8).

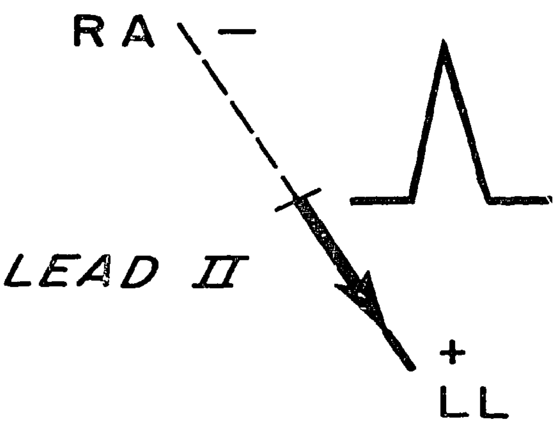


Figure 7

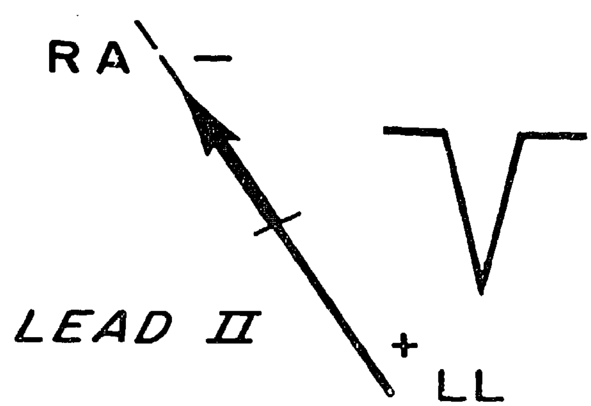


Figure 8

2.3 *Lead III*

Lead III is a bipolar lead with its positive electrode located on the left leg and its negative electrode on the left arm (Figure 9).

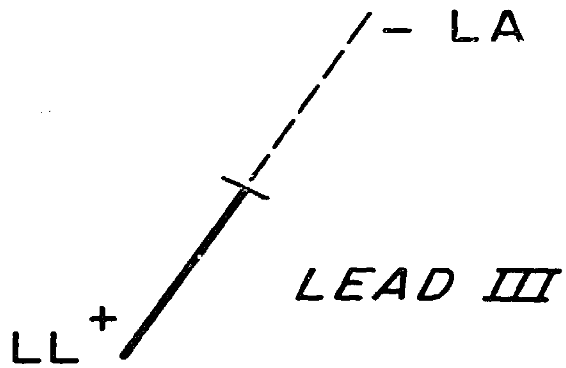


Figure 9

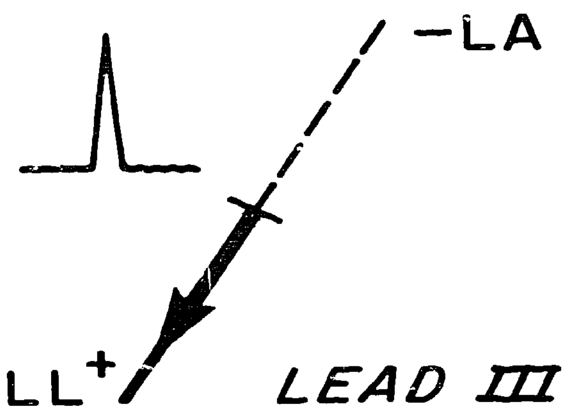


Figure 10

Since the positive electrode is on the left leg, an upright deflection in lead III must represent QRS forces moving toward the left leg (Figure 10).

A negative deflection in lead III represents QRS forces moving toward the negative electrode, i.e., toward the left arm (Figure 11).

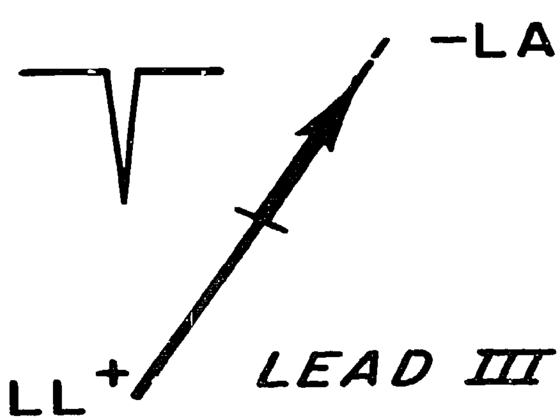


Figure 11

3. THE EINTHOVEN TRIANGLE

Extremity leads I, II, and III are bipolar leads. Each lead has its own positive and negative electrodes which may be affixed anywhere on the extremities. The *effective locations* of the right and left arm electrodes are at the shoulders and the effective location of the left leg electrode is at the symphysis pubis. Lines joining these electrode locations, at the shoulders and the symphysis pubis, result in an equilateral triangle known as the *Einthoven Triangle* (Figure 12). The three lines of the Einthoven Triangle comprise the *axes of extremity leads I, II, and III.*

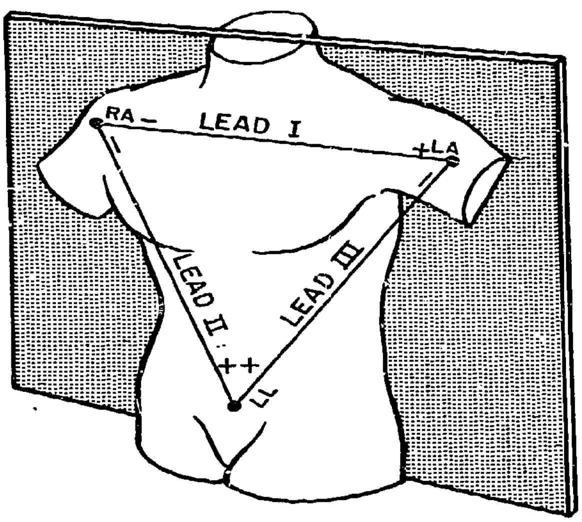
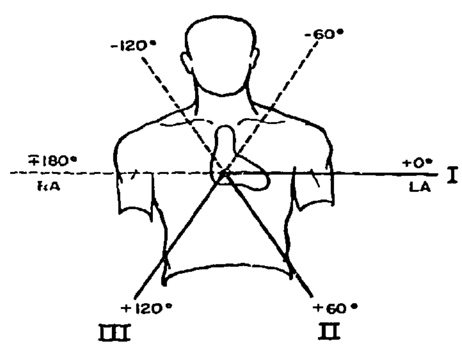


Figure 12

4. TRIAXIAL REFERENCE FIGURE

For Spatial Analysis, the three sides of the Einthoven Triangle, the axes of leads I, II, and III, may be redrawn passing through a common point located in the center of the heart. The direction of each lead in degrees and the locations of the positive electrodes may be added to obtain the Triaxial Reference Figure (Figure 13).



TRIAXIAL REFERENCE FIGURE

Figure 13

5. BIPOLAR LEADS—AXES AND FIELDS

5.1 *Lead I Axis*

The axis of lead I may be divided into a positive and negative portion by a perpendicular line through its center (Figure 14).

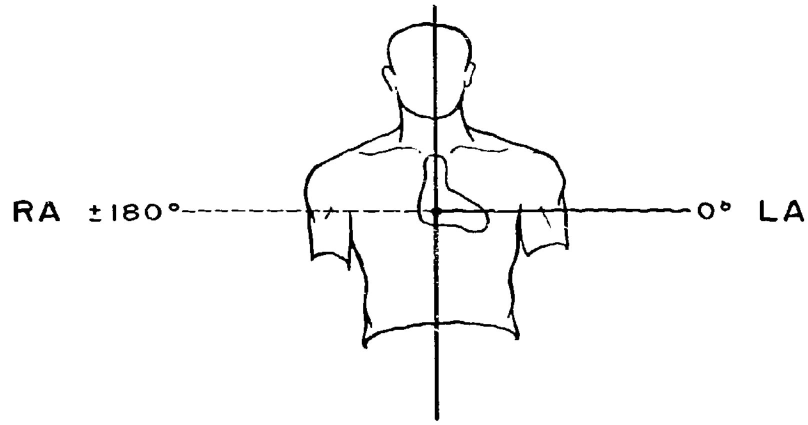


Figure 14

Since the positive electrode of lead I is located on the left shoulder, the positive portion of the lead I axis must lie on the left side of this perpendicular line, at 0° (Figure 15). The negative portion is located rightward at 180°.

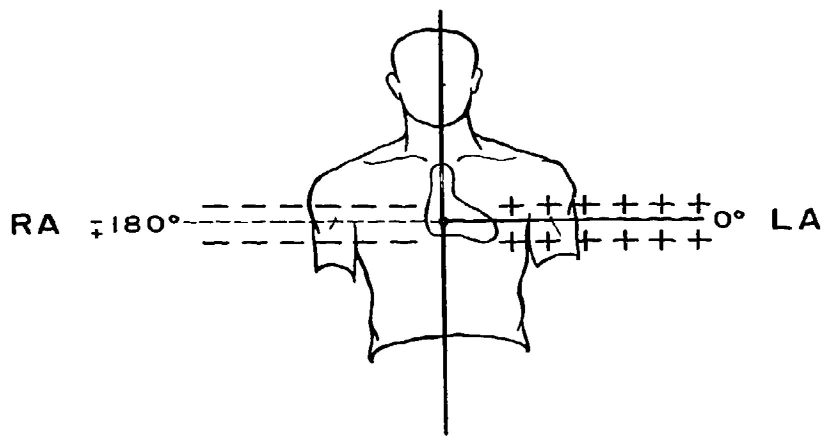


Figure 15

5.2. *Lead I Field*

The perpendicular line through the center of the lead I axis also divides the body into a positive and a negative portion or *field* (Figure 16).

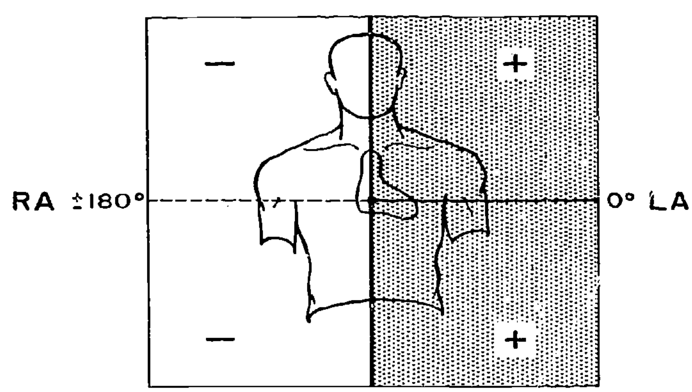


Figure 16

A QRS force or a vector located within the positive portion of the lead I field must represent QRS forces moving toward the positive electrode of lead I and hence must give rise to an upright deflection in this lead (Figure 17).

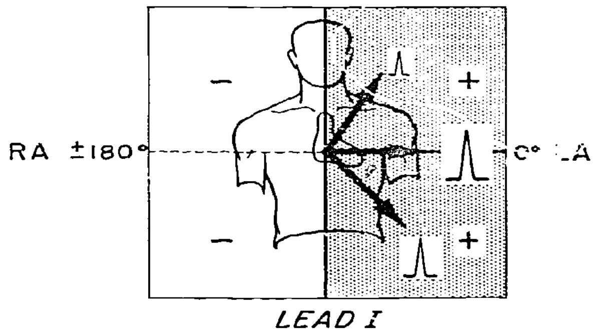


Figure 17

A negative deflection, a Q or an S wave, results from a vector moving toward the negative electrode and hence lying within the negative field of lead I (Figure 18).

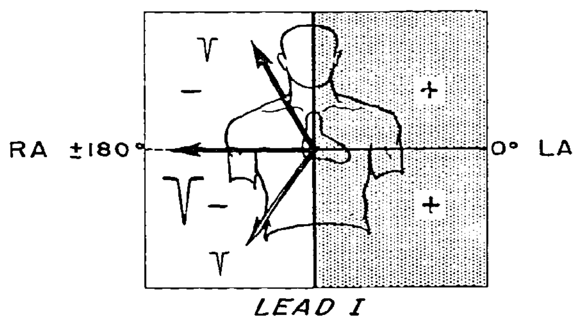


Figure 18

5.3 *Lead II Axis*

The positive and negative electrodes of lead II are located respectively on the left leg and the right arm. The effective spatial locations are the symphysis pubis and right shoulder respectively (Figure 19).

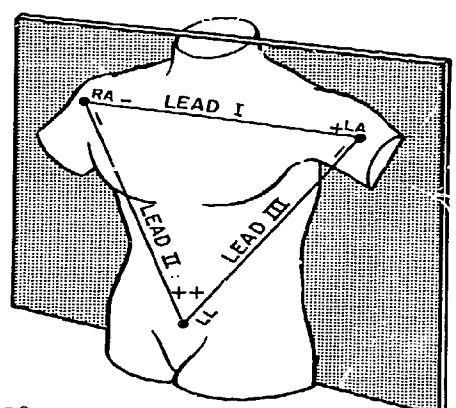
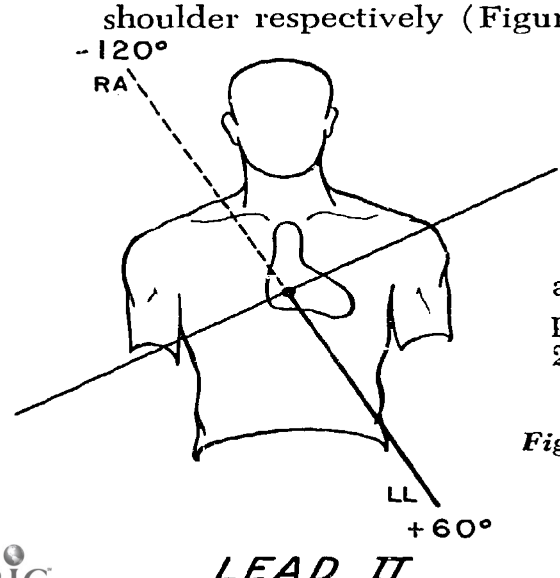


Figure 19



The axis of lead II may be divided into a positive and a negative portion by a perpendicular line through its center (Figure 20).

Figure 20

Since the positive electrode of lead II is located on the left leg and the effective spatial location is the symphysis pubis, the positive portion of the lead II axis must lie on the left and inferior side of the perpendicular line, at +60° (Figure 21). The negative portion of the lead II axis is located right and superior at −120°.

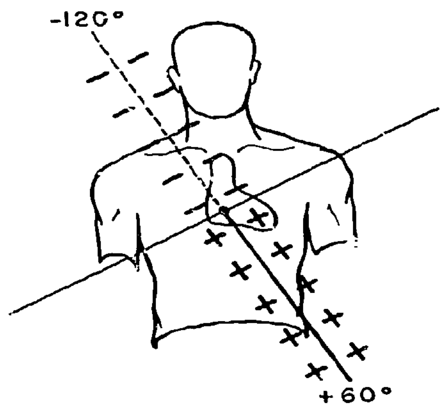


Figure 21

5.4 *Lead II Field*

The perpendicular line through the center of the lead II axis also divides the body into a positive and a negative field (Figure 22).

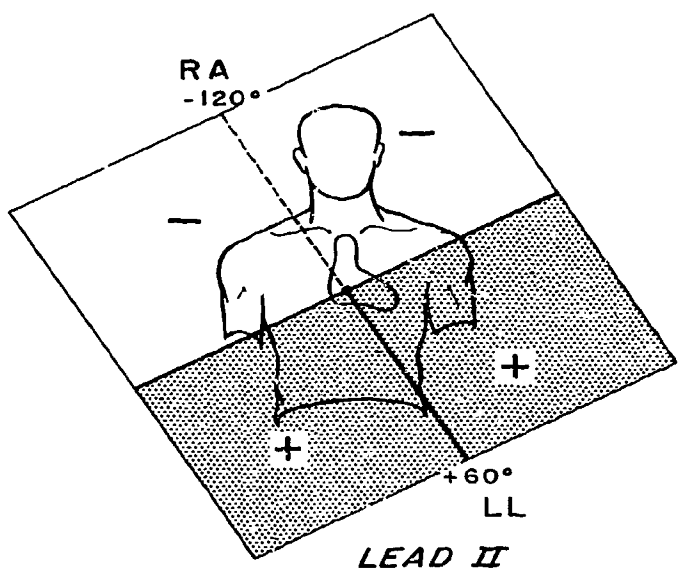


Figure 22

An upright deflection in lead II must represent a QRS vector moving toward the positive portion of the lead II field (Figure 23).

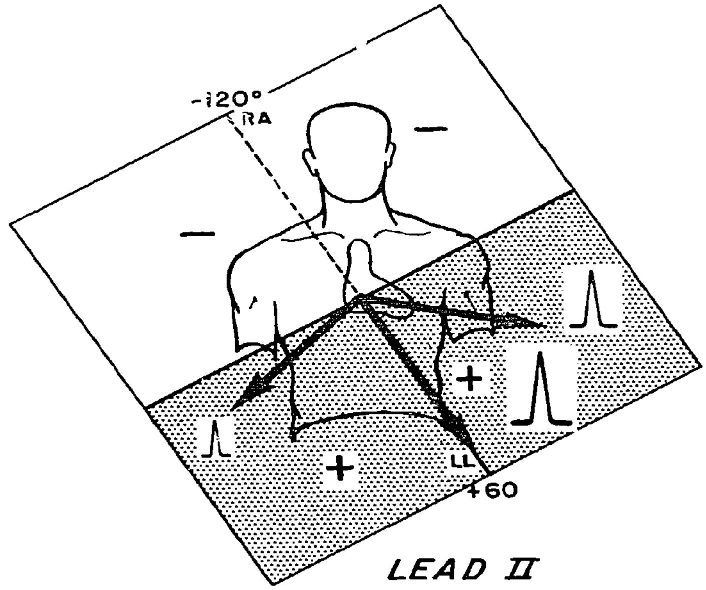


Figure 23

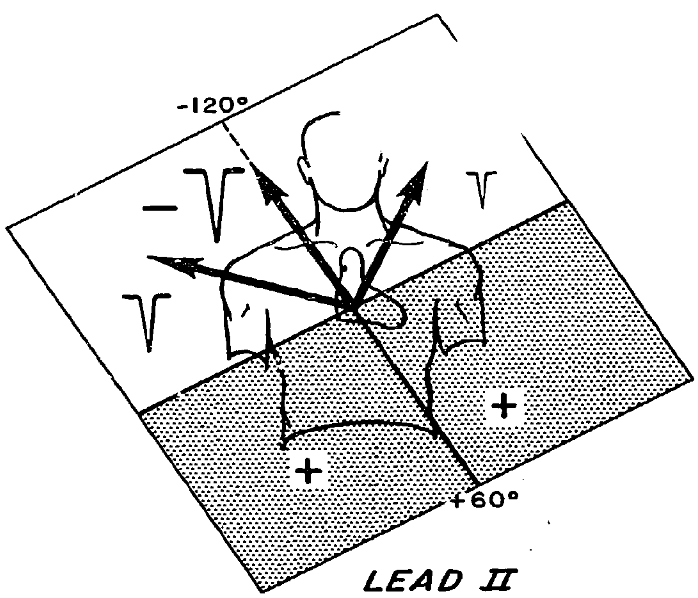


Figure 24

A negative deflection must represent a QRS vector moving toward the negative electrode of lead II and hence lying within the negative field of lead II (Figure 24).

5.5 Lead III Axis

The positive and negative electrodes of lead III are located respectively on the left leg and the left arm. The effective spatial locations are the symphysis pubis and the left shoulder (Figure 25).

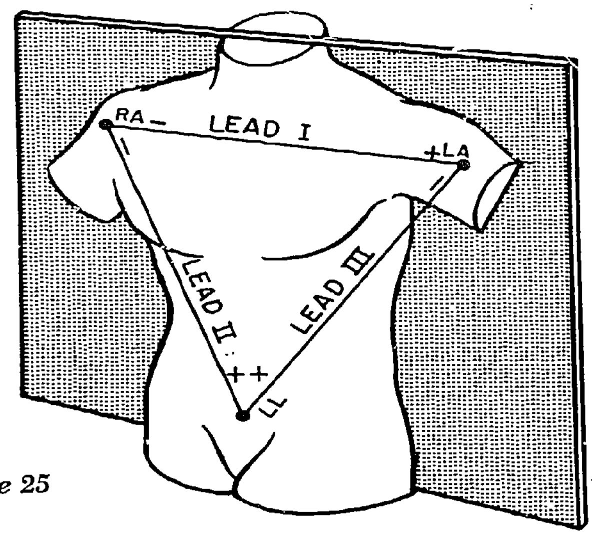


Figure 25

The axis of lead III may be divided into a positive and a negative portion by a perpendicular line through its center (Figure 26).

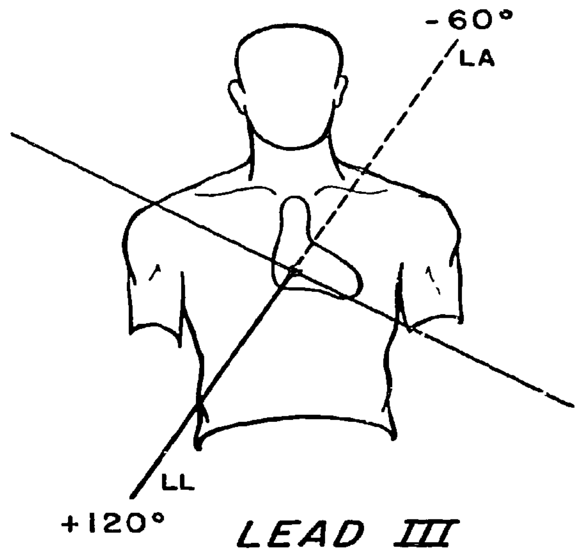


Figure 26

Since the positive electrode of lead III is located on the left leg, and the effective spatial location is the symphysis pubis, the positive portion of the lead III axis must lie right and inferior at +120°. The negative portion of the lead III axis is located left and superior at –60° (Figure 27).

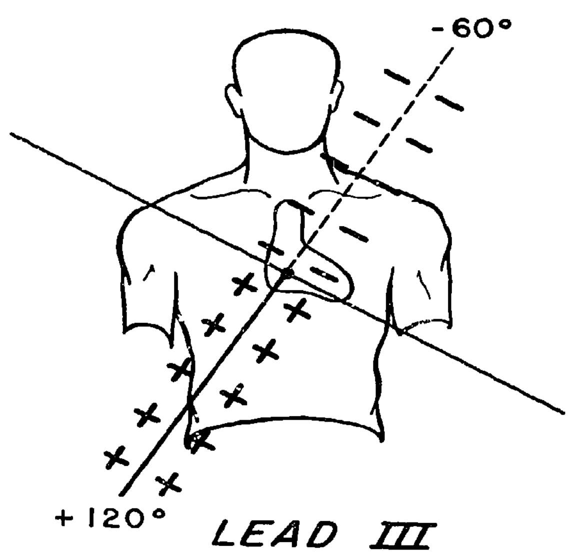


Figure 27

5.6 *Lead III Field*

The perpendicular line through the center of the lead III axis also divides the body into a positive and a negative field (Figure 28).

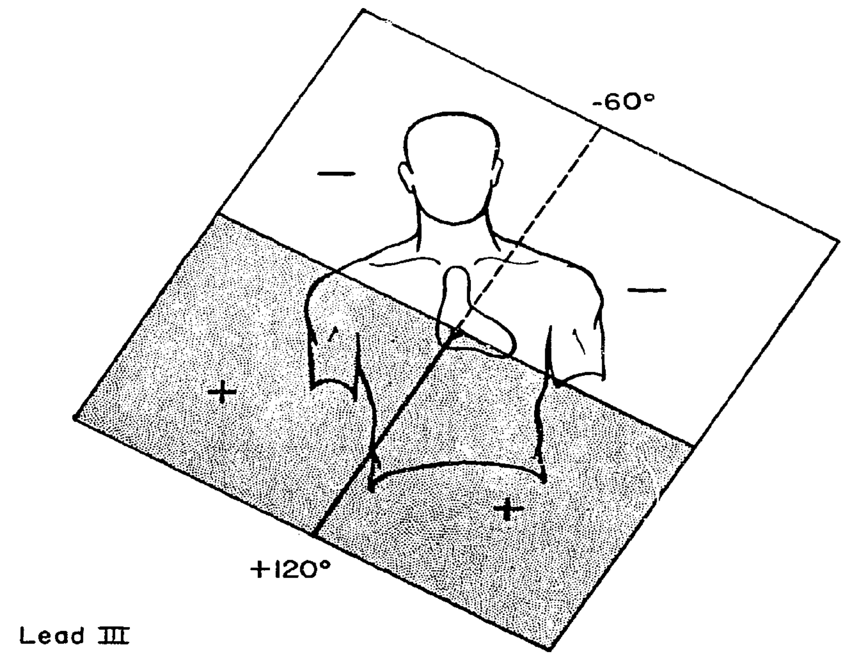


Figure 28

A QRS vector lying within the positive field of lea III must be moving toward the positive electrode and hence must give rise to an upright deflection in this lead (Figure 29).

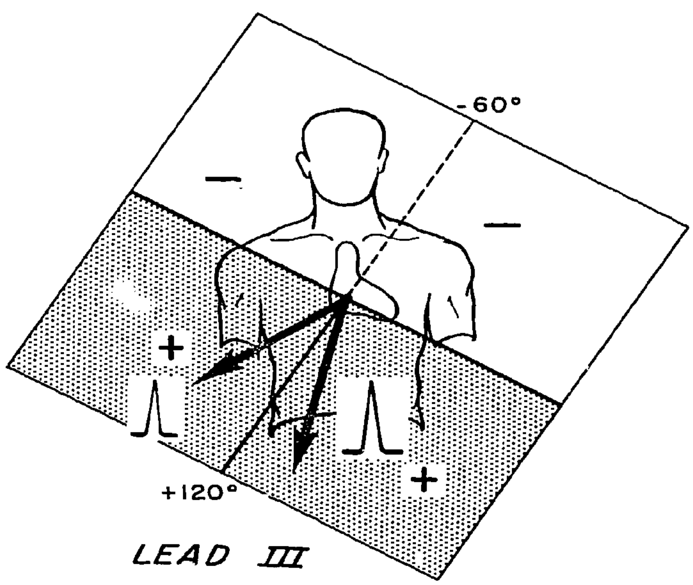


Figure 29

A negative deflection indicates QRS forces are moving toward the negative electrode and hence lying within the negative field of lead III (Figure 30).

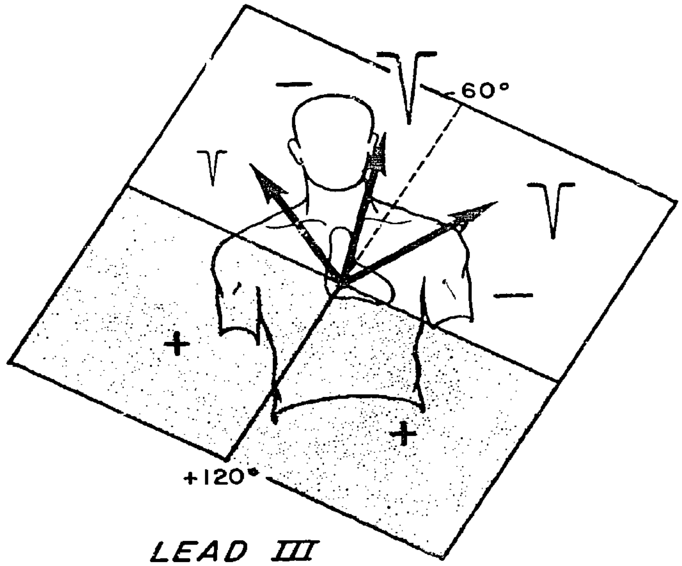


Figure 30

6. UNIPOLAR LEADS

6.1 *Orientation of Unipolar Leads*

Extremity leads I, II, and III, are bipolar leads, each having its own positive and negative electrodes. The unipolar extremity leads, AVR, AVL and AVF, on the other hand, are recorded with their positive electrodes located on their respective extremities, right arm, left arm, and left leg. The negative electrode of each unipolar lead is a central terminal assumed to be located within the heart (Figure 31). The effective spatial location of the negative electrode is 180° opposite the positive electrode of each unipolar lead.

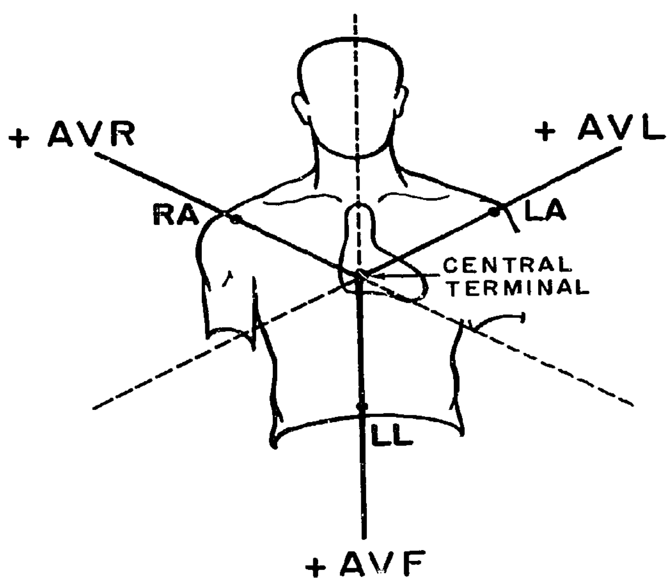


Figure 31

6.2 *Orientation of Lead AVF*

An upright deflection in lead AVF represents a vector moving toward the positive electrode of this lead (Figure 32). The positive electrode of lead AVF is located on the left leg; the effective spatial location of the positive electrode is the symphysis pubis. *An upright deflection in lead AVF,* therefore, must indicate forces moving inferior toward the *symphysis pubis.*

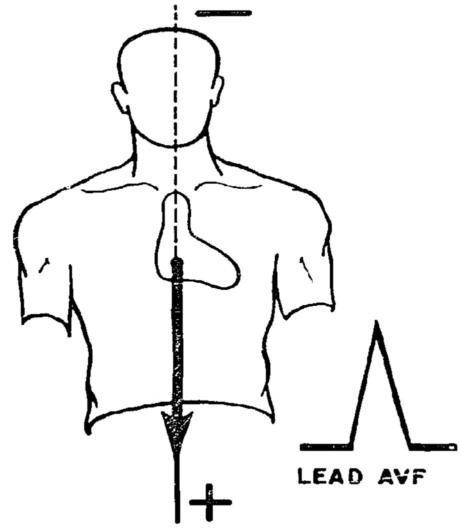


Figure 32

A vector moving superior, away from the positive electrode (Figure 33), must give rise to a negative deflection in lead AVF.

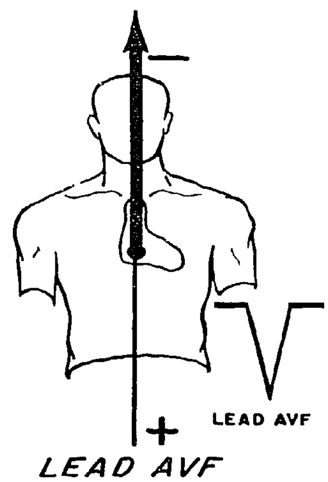


Figure 33

6.3 *Orientation of Lead AVL*

The positive electrode of lead AVL is located on the left arm and its effective spatial location is the left shoulder. An upright deflection in *lead AVL* indicates a vector moving toward the positive electrode and hence toward the left shoulder (Figure 34).

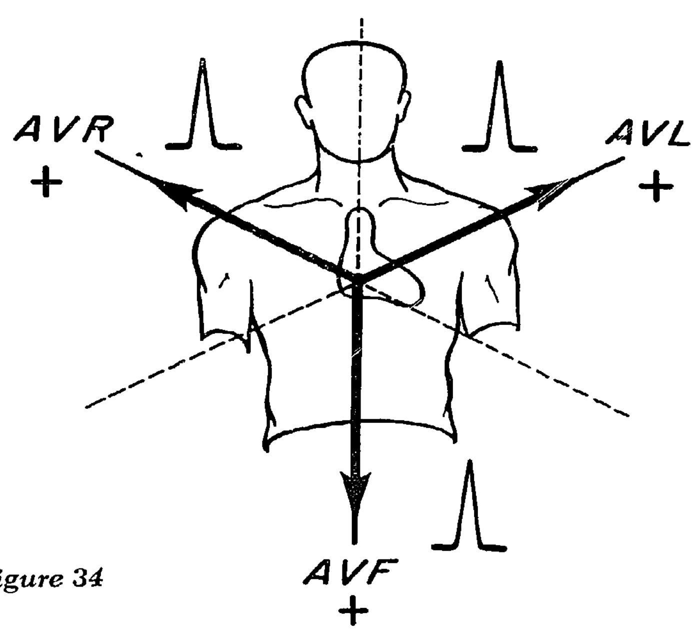


Figure 34

6.4 *Orientation of Lead AVR*

The positive electrode of lead AVR is on the right arm. Its effective spatial location is the right shoulder. An upright deflection in *lead AVR* must indicate a vector moving toward the positive electrode of the lead and, hence, toward the right shoulder (Figure 35).

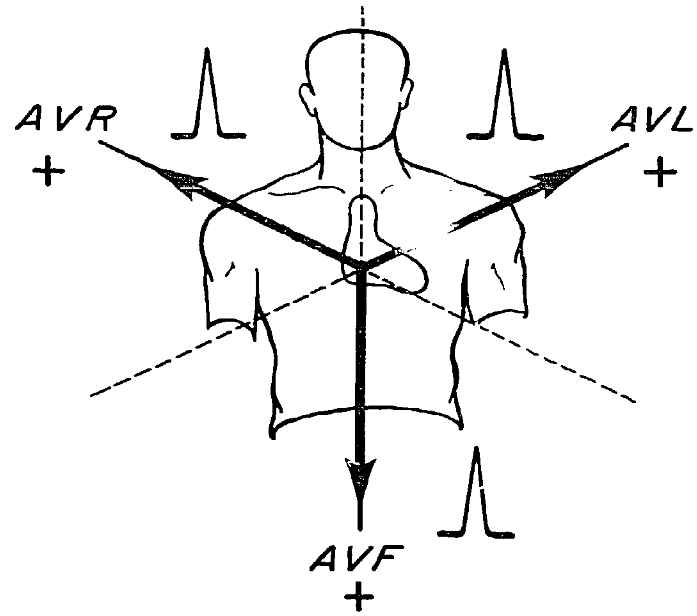


Figure 35

7. *Frontal Plane*

Leads I, II, and III are bipolar leads obtained from electrodes located on the extremities. These leads lie in the frontal plane of the body (Figure 36).

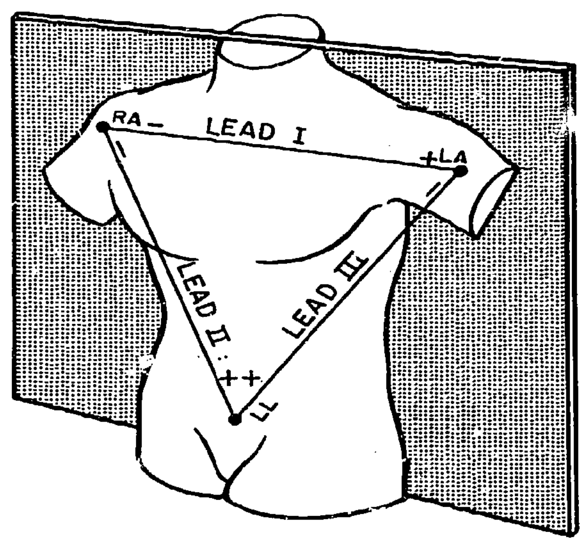


Figure 36

The frontal plane divides the body into a front and back half. It is defined by two axes, left-right and superior-inferior. Leads AVR, AVL, and AVF are unipolar leads derived from the electrodes located on these same extremities and, therefore, also lie in the frontal plane (Figure 37).

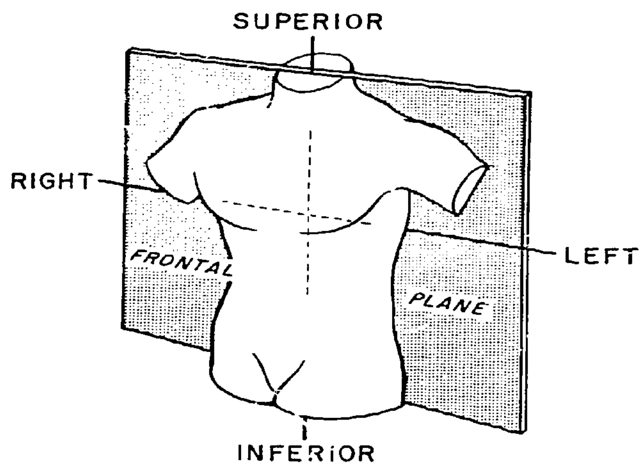
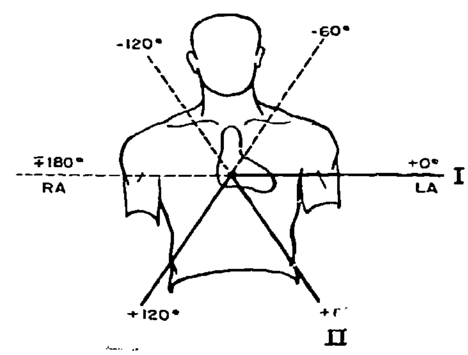


Figure 37

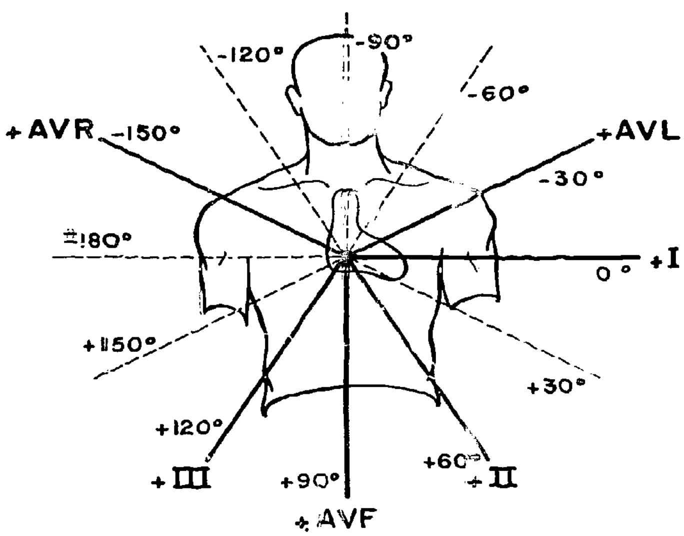
8. *Hexaxial Frontal Plane Reference Figure*

The axes of bipolar leads I, II, and III, when drawn through a commonpoint, the center of the heart, produce the triaxial reference figure (Figure 38).



TRIAXIAL REFERENCE FIGURE

Figure 38



FRONTAL PLANE

Figure 39

Since unipolar leads AVR, AVL, and AVF also lie in the frontal plane, the axes of these leads may be added to the triaxial reference figure. This results in a *hexaxial frontal plane reference figure* indicating the directions and the positive poles of all the bipolar and unipolar leads (Figure 39).

The frontal plane reference figure will play an important part in the *Method of Spatial Analysis*.

9. UNIPOLAR LEADS—AXES AND FIELDS

9.1 *Lead AVF Axis*

The positive electrode of lead AVF is located on the left leg; the effective spatial position of the left leg electrode is the symphysis pubis. The negative electrode is a central terminal whose spatial location is 180° opposite its positive electrode (Figure 40).

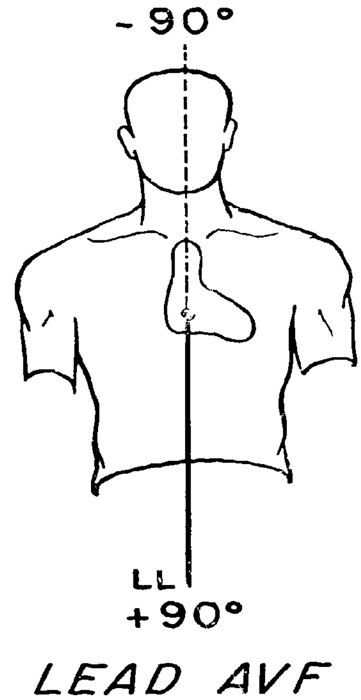


Figure 40

The axis of lead AVF may be divided into a positive and a negative portion by a perpendicular line through its center (Figure 41).

The positive portion lies adjacent to the positive electrode and hence is inferior at +90°. The negative portion is superior at −90°.

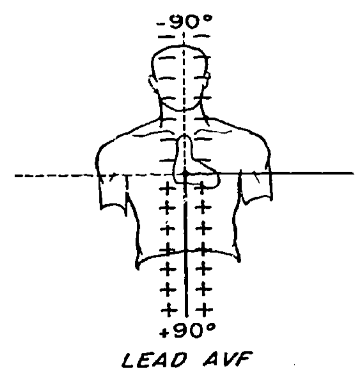


Figure 41

9.2 *Lead AVF Field*

The perpendicular line through the center of the lead AVF axis also divides the body into a positive and a negative field (Figure 42).

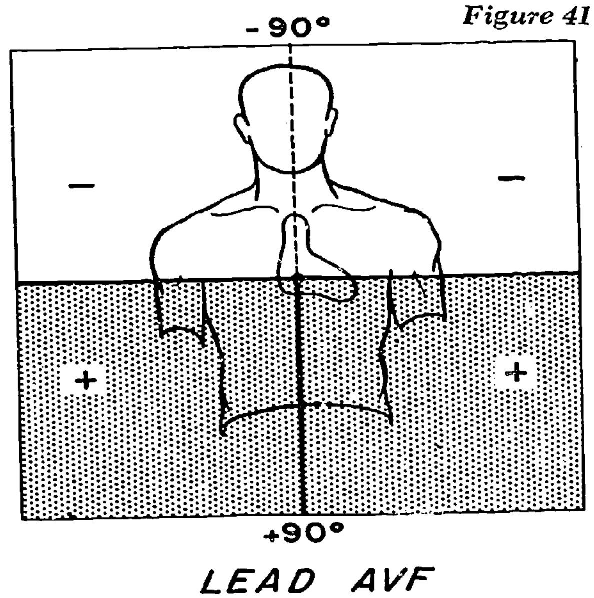


Figure 42

A vector located inferior between 0 and $+180°$ therefore must be moving toward the positive electrode of this lead and hence must give rise to an upright deflection (Figure 43).

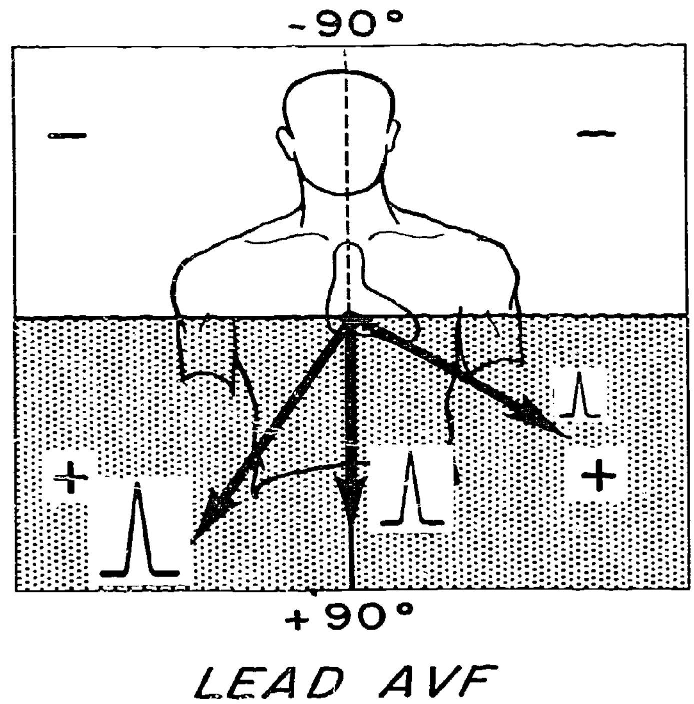


Figure 43

A QRS vector oriented superior is moving away from the positive electrode and hence is lying within the negative field of lead AVF; it therefore must give rise to a negative deflection in this lead (Figure 44).

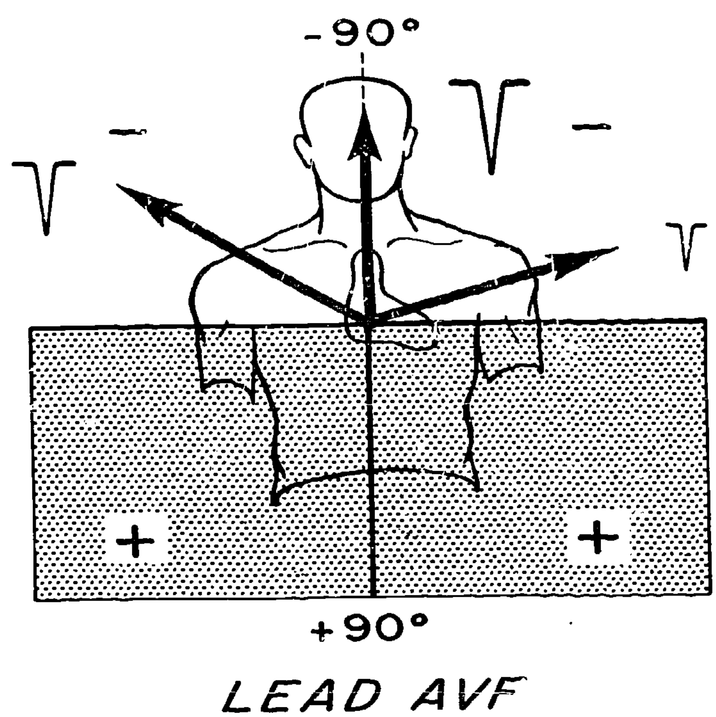


Figure 44

9.3 *Lead AVL Axis*

The axis of lead AVL may be divided into a positive and a negative portion by a perpendicular line through its center (Figure 45).

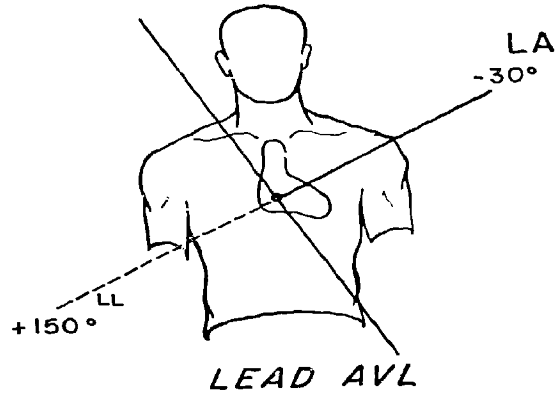


Figure 45

Since the positive electrode of lead AVL is located on the left arm and its effective spatial location is the left shoulder, the positive portion of the lead AVL axis must be left and superior at −30° (Figure 46). The negative portion of the AVL axis is located right and inferior at +150°.

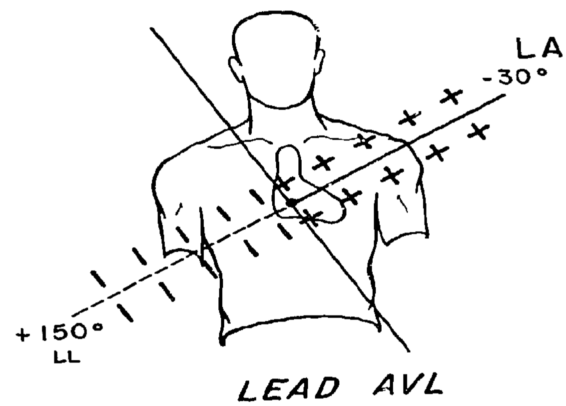


Figure 46

9.4 *Lead AVL Field*

The perpendicular line through the center of the lead AVL axis also divides the body into a positive and a negative field. A vector lying within the positive field must be moving toward the positive electrode of lead AVL and therefore must produce an upright deflection in this lead (Figure 47).

A vector located within the negative field of lead AVL must be moving away from the positive electrode and hence will give rise to a negative deflection in this lead.

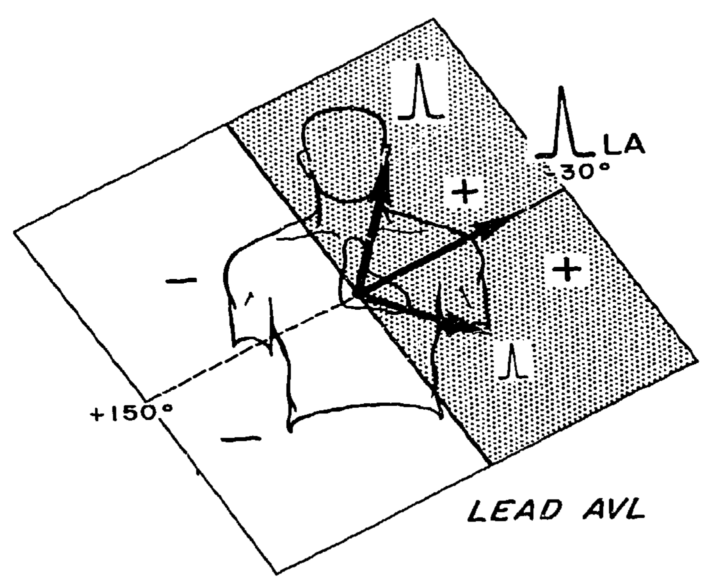


Figure 47

9.5 *Lead AVR Axis*

The axis of lead AVR also may be divided into a positive and a negative portion (Figure 48). Since the positive electrode of lead AVR is located on the right arm and its effective spatial position is the right shoulder, the positive portion of the lead AVR axis is right and superior at −150° (Figure 49). The negative portion of the lead AVR axis is opposite, left and inferior at +30°.

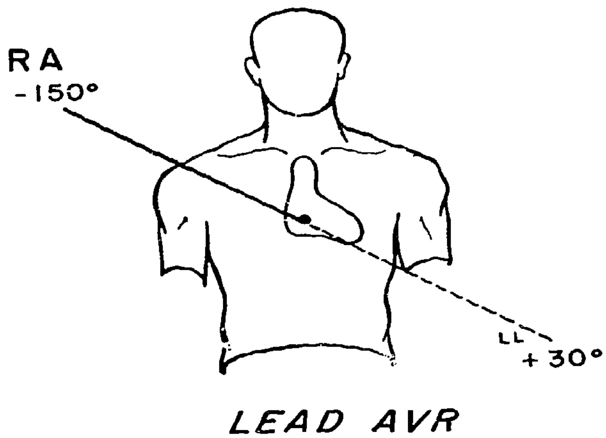


Figure 48

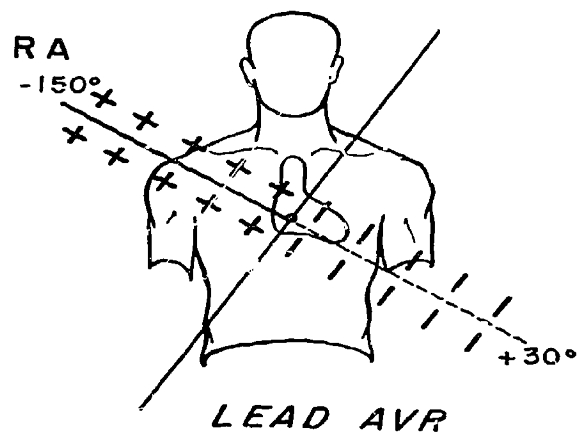


Figure 49

9.6 *Lead AVR Field*

The perpendicular line through the center of the lead AVR axis also divides the body into a positive and a negative field (Figure 50). A vector lying within the positive field of lead AVR must be moving toward the positive electrode of this lead and hence must give rise to an upright deflection.

A vector located within the negative field of lead AVR is moving away from the positive electrode and hence must give rise to a negative deflection in this lead.

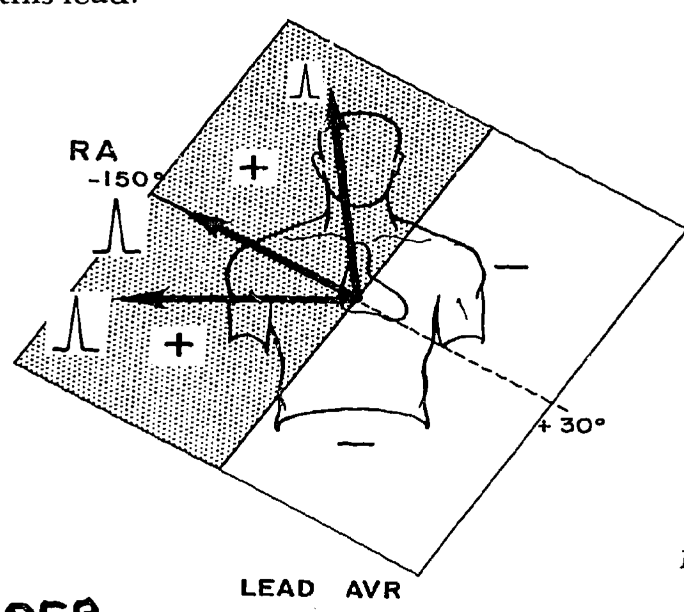


Figure 50

10. FRONTAL PLANE LEADS

10.1 *Frontal Plane Axes*

Bipolar leads I, II, and III, and unipolar leads AVR, AVL and AVF lie in the frontal plane of the body. The frontal plane consists of left-right and superior-inferior axes (Figure 51).

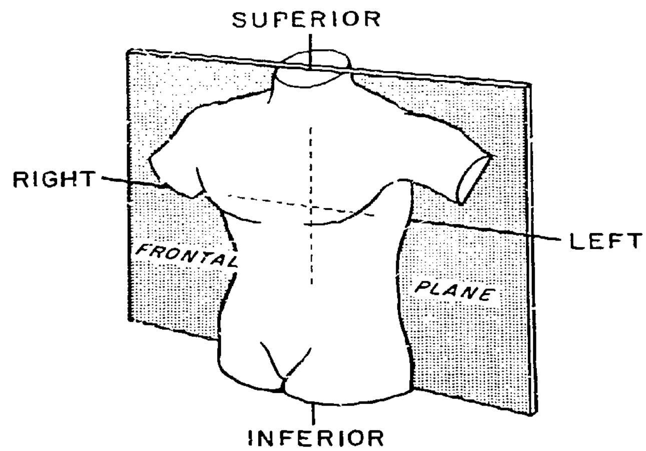


Figure 51

The frontal plane reference figure (Figure 52) demonstrates the bipolar and unipolar leads and their respective axes in degrees.

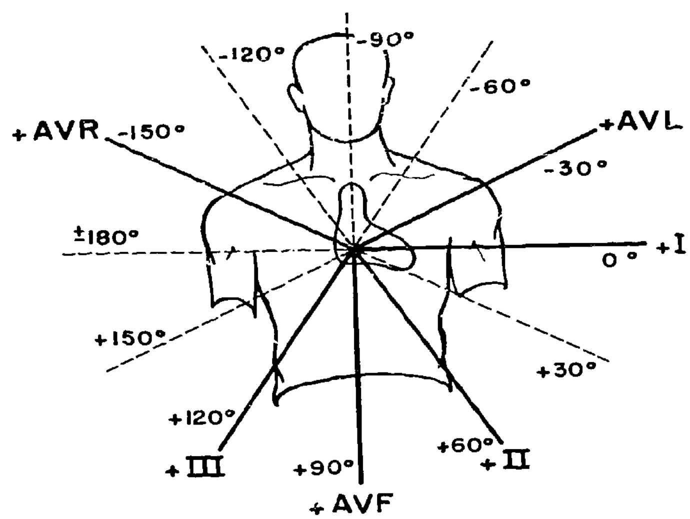


Figure 52

10.2 *Best Left-Right Lead*

Lead I is oriented along the 0 to +180° axis and represents a left-right lead without superior or inferior tilt (Figure 53). Lead I, for Spatial Analysis, is the best left-right lead in the frontal plane.

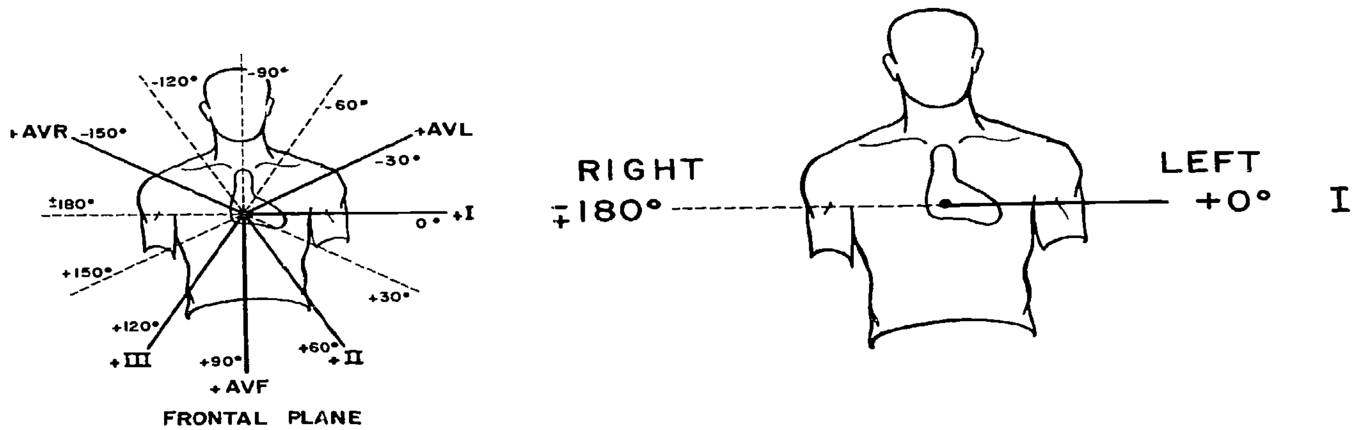


Figure 53

The positive portion of the lead II axis is located at +60° and the negative portion at −120° (Figure 54). Lead II primarily is a superior-inferior lead with a left-right tilt and therefore is not the best left-right lead.

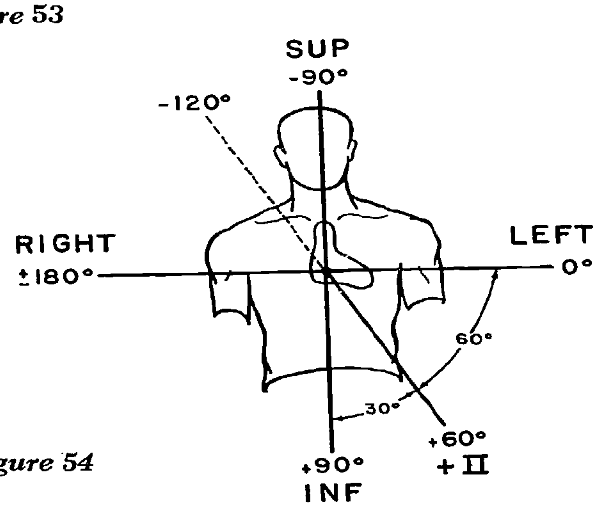


Figure 54

The positive portion of the lead III axis is located right and inferior +120° and the negative portion is left and superior at −60° (Figure 55). Lead III, therefore, is a superior-inferior lead with a left-right tilt and also is not the best left-right lead.

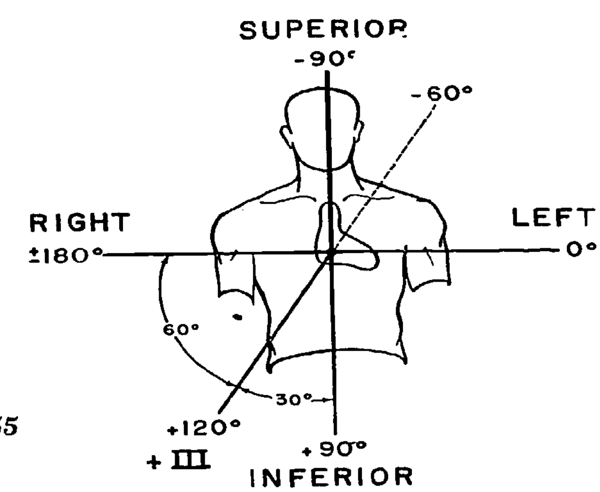


Figure 55

10.3 *Best Superior-Inferior Lead*

The positive electrode of lead AVF is located on the left leg; the effective spatial location of the positive electrode is the symphysis pubis. The positive portion of the lead AVF axis is inferior at +90° and the negative portion is superior at –90° (Figure 56). *Lead AVF,* therefore, is a superior-inferior lead without left-right tilt.

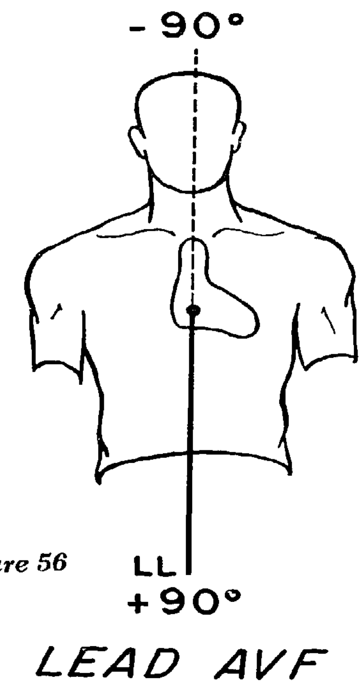


Figure 56

The positive electrode of lead AVL is located on the left arm and its effective spatial location is the left shoulder. The positive portion of the lead AVL axis is left and superior –30°. The axis of lead AVL is tilted 60° from the vertical and 30° from the left-right axis. Lead AVL, therefore, is primarily a left-right lead with a superior-inferior tilt and is not the best superior-inferior lead (Figure 57).

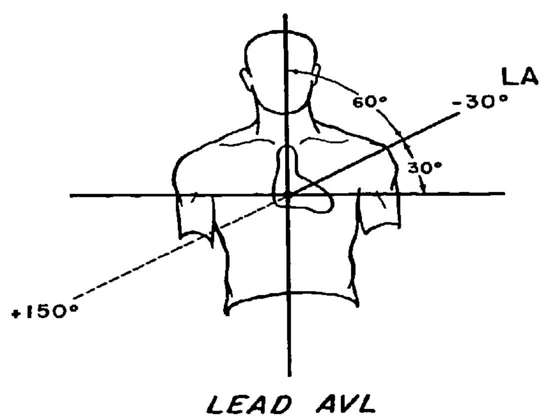


Figure 57

The positive electrode of lead AVR is located on the right arm; its effective spatial location is the right shoulder. The positive portion of the lead AVR axis is right and superior at –150° (Figure 58). The axis of lead AVR is tilted 60° from the vertical and 30° from the left-right axis. Lead AVR is primarily a left-right lead with a superior-inferior tilt, and, therefore, is not the best superior-inferior lead.

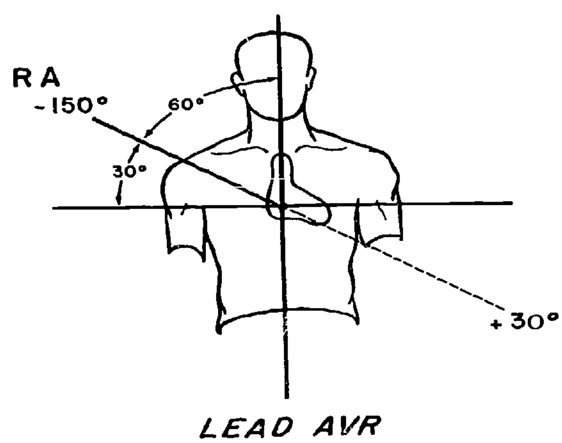


Figure 58

10.4 *Best Frontal Plane Reference Leads*

Leads I and AVF, for Spatial Analysis, are the best frontal plane leads for determining vectors along the left-right and superior-inferior axes of the body (Figure 59). These leads define the frontal plane.

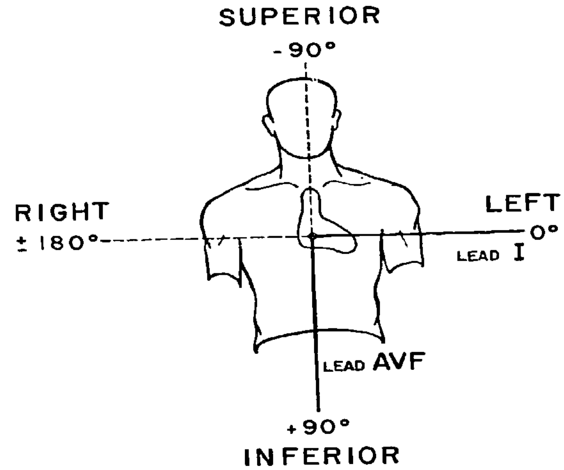


Figure 59

Leads II and III primarily are superior-inferior leads with a left-right tilt.

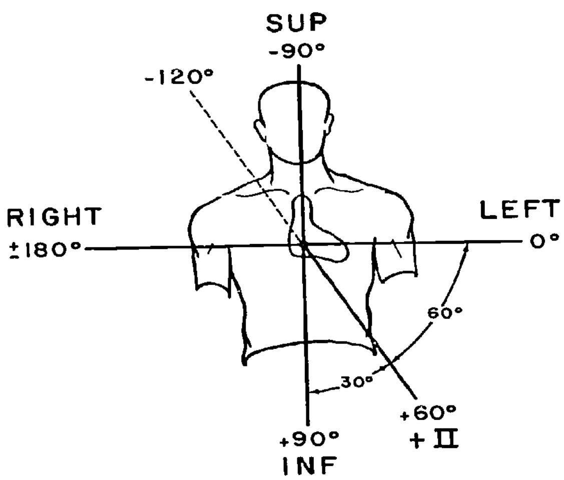


Figure 60

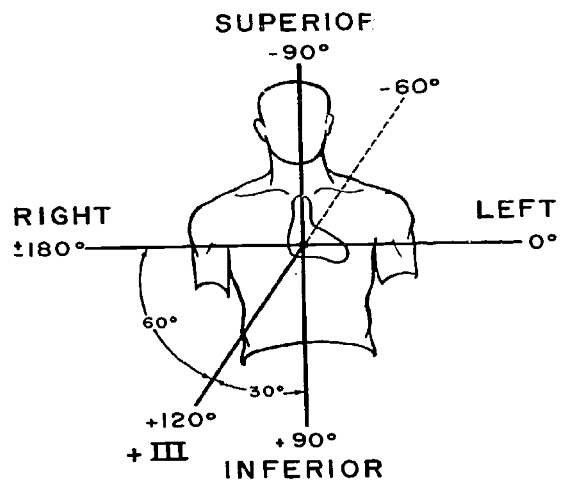
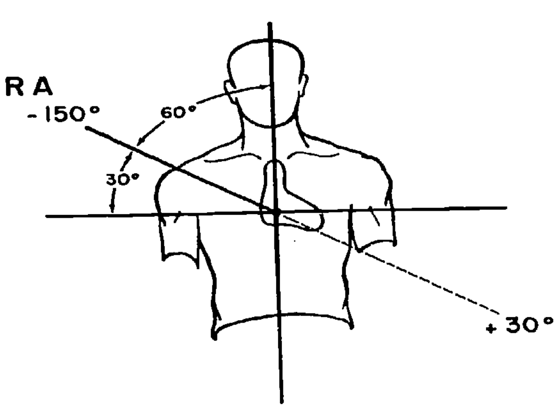


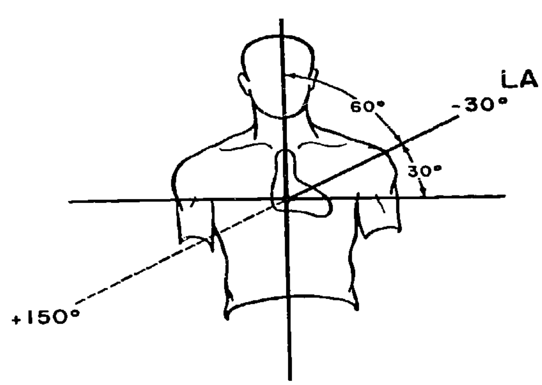
Figure 61

Leads AVR and AVL primarily are left-right leads with a superior-inferior tilt.



LEAD AVR

Figure 62



LEAD AVL

Figure 63

Section II

MEAN FRONTAL QRS VECTOR

1. *Mean QRS Vector*

Each QRS complex in the electrocardiogram represents activation of the ventricles. During activation of the ventricles, an infinite number of QRS vectors are produced (Figure 64). These instantaneous QRS vectors are conducted to all portions of the body and are represented in all leads.

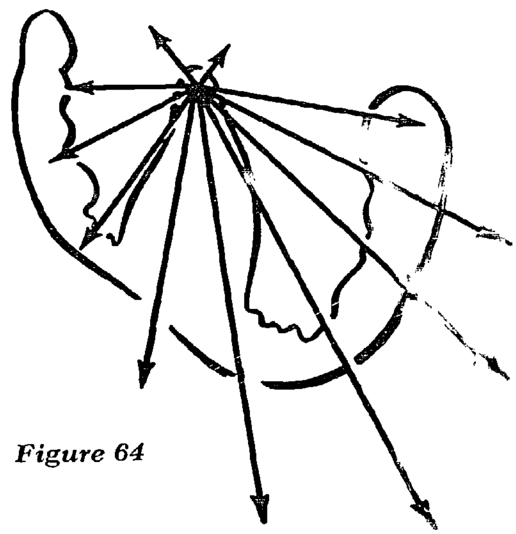


Figure 64

All instantaneous QRS vectors produced during one ventricular activation may be added, resulting in a *single QRS vector* having a *specific direction in space* (Figure 65). This single vector is called the *mean QRS vector;* the direction of the mean QRS vector is important in the diagnosis of heart disease.

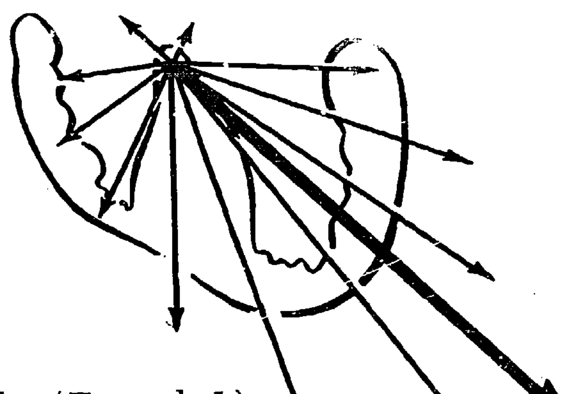


Figure 65

2. *Mean Frontal QRS Vector—Quadrant Rule—*(Example 1)

The mean frontal QRS vector of any electrocardiogram may be located by the *Quadrant and Perpendicular Rules of Spatial Analysis.* The Quadrant Rule localizes the mean QRS vector to one of the four frontal plane quadrants (Figure 66). This localization may be accomplished by utilizing the two leads best representing left-right and superior-inferior axes of the body, leads I and AVF, respectively.

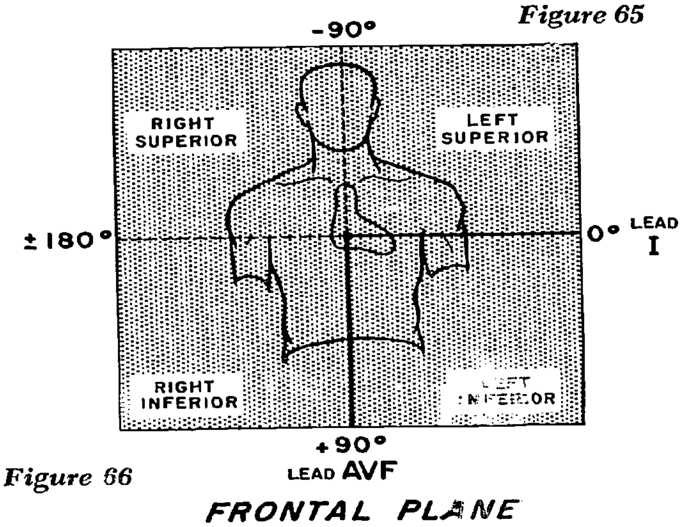


Figure 66

2.1 *Left-Right QRS Vector*

The mean frontal QRS vector of any electrocardiogram may be determined with the Quadrant Rule of Spatial Analysis. Frontal plane leads from an electrocardiogram are presented below (Figure 67).

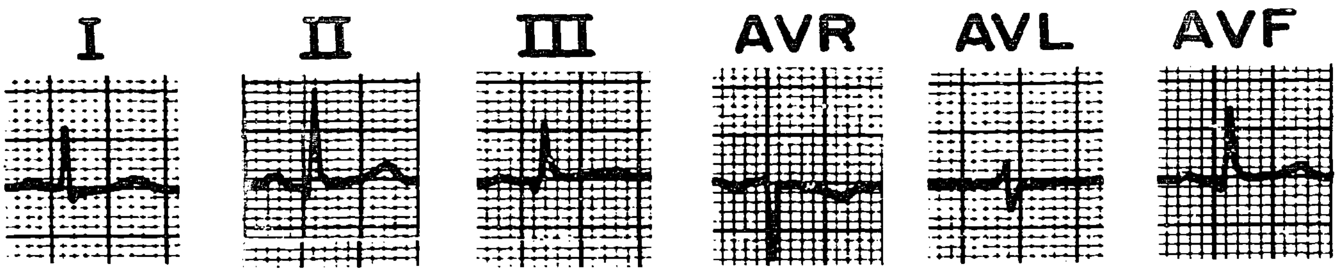


Figure 67

Lead I displays a large R wave and a small S wave; the predominant deflection is *positive*. A net positive deflection in lead I indicates QRS vectors are moving toward the positive electrode of that lead. Since the positive electrode of lead I is located on the left arm, the predominant R wave (Figure 68) must indicate QRS forces are left.

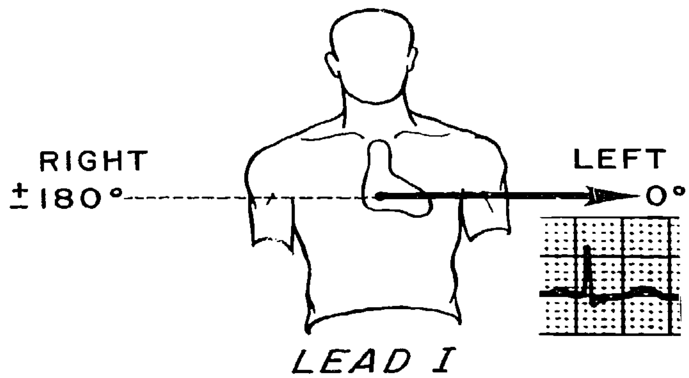


Figure 68

The mean frontal QRS vector in this electrocardiogram cannot be rightward since this demands a predominate negative deflection in lead I (Figure 69). Lead I does not display a predominant negative QRS deflection.

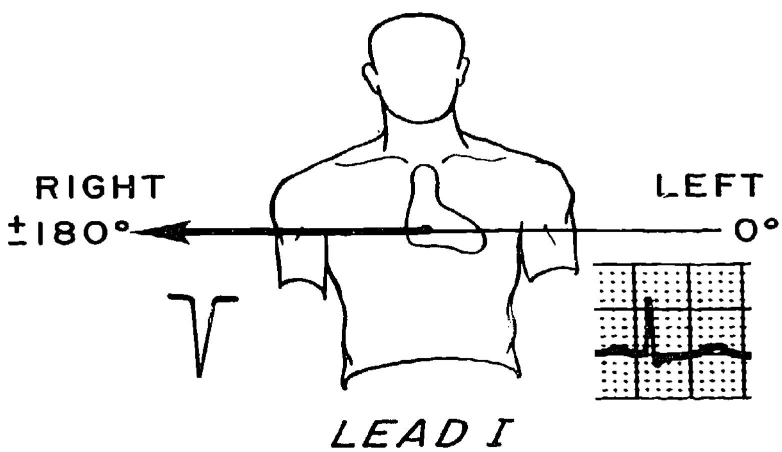


Figure 69

2.2 *Superior-Inferior QRS Vector*

In the same electrocardiogram (Figure 70), the predominant upright deflection in lead AVF indicates QRS forces are moving toward the positive electrode of this lead.

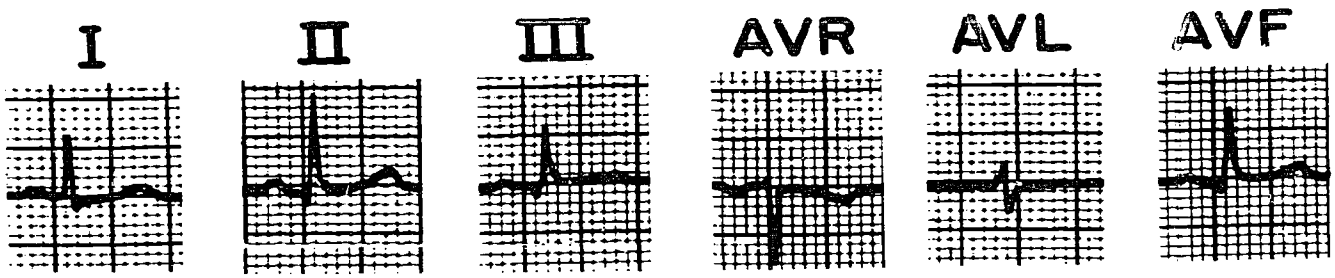


Figure 70

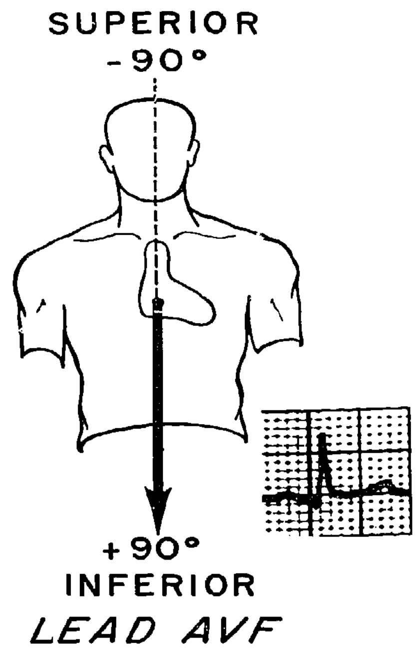


Figure 71

Since the positive electrode is located on the left leg and since its effective spatial position is at the symphysis pubis, net QRS forces in lead AVF must be moving inferior (Figure 71).

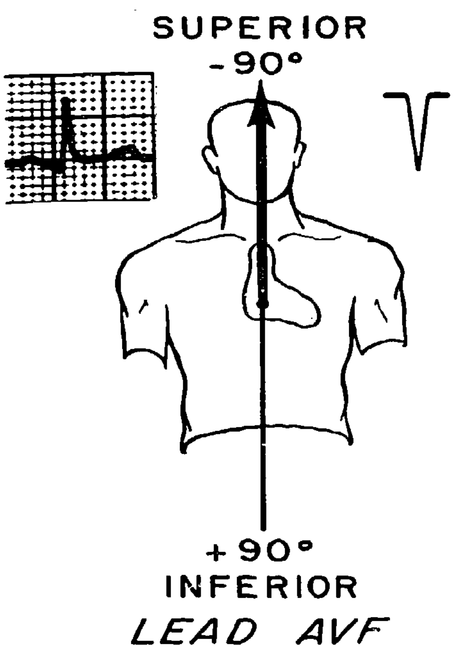


Figure 72

Lead AVF in this tracing *cannot* represent a superior QRS vector (Figure 72) since this would demand a predominant negative deflection in this lead. The QRS complex in lead AVF of this tracing is not a predominant negative deflection.

2.3 *Mean Frontal QRS Vector*

The mean frontal QRS vector may be localized to a quadrant by combining the net QRS vectors determined from the left-right and superior-inferior leads. In this tracing the net direction of QRS forces along the left-right axis was determined to be *left* (upright deflection in lead I). The net direction of QRS forces along the superior-inferior axis was determined to be *inferior* (large R wave in lead AVF). Combining these net left-right and superior - inferior forces (Figure 73), localizes the *mean frontal QRS vector to the left and inferior quadrant.* The Quadrant Rule is the first step in determining the mean frontal QRS vector.

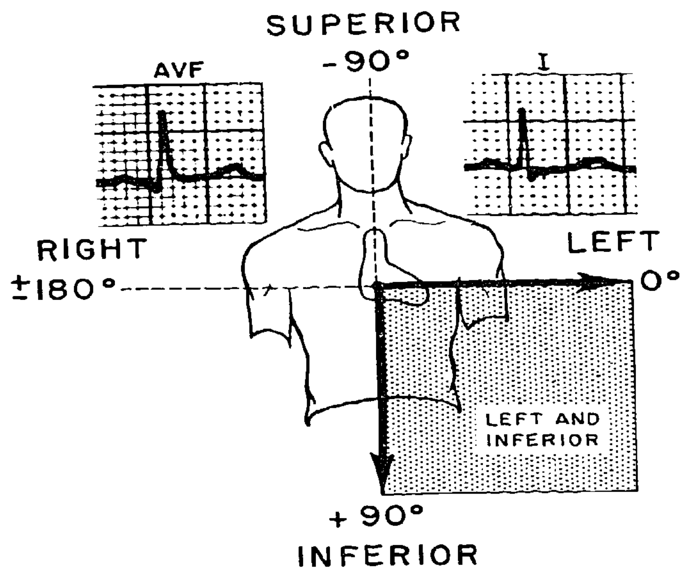


Figure 73

3. MEAN FRONTAL QRS VECTOR-PERPENDICULAR RULE (Example I)

3.1 *Importance of the Equiphasic QRS Complex*

An upright deflection in any lead indicates QRS forces are moving toward the positive electrode of that lead; a negative deflection indicates QRS forces are moving away from the positive electrode. An *Equiphasic Complex* (Figure 74) is one in which the area under the positive deflection and the area under the negative deflection are equal. When added, the positive and negative areas are zero, indicating *net* QRS forces must be moving *perpendicular to the axis of this lead.*

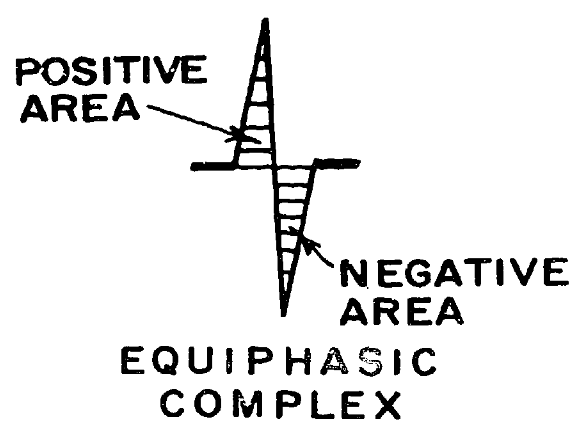


Figure 74

3.2 *The Perpendicular Rule*

The Perpendicular Rule of Spatial Analysis is used to localize the mean QRS vector in degrees. The Perpendicular Rule states: *The mean QRS vector lies perpendicular to the lead with the equiphasic complex and in the preselected quadrant.* In this same tracing (Figure 75), the QRS complex in lead AVL is equiphasic (i.e. the net positive and negative area is zero).

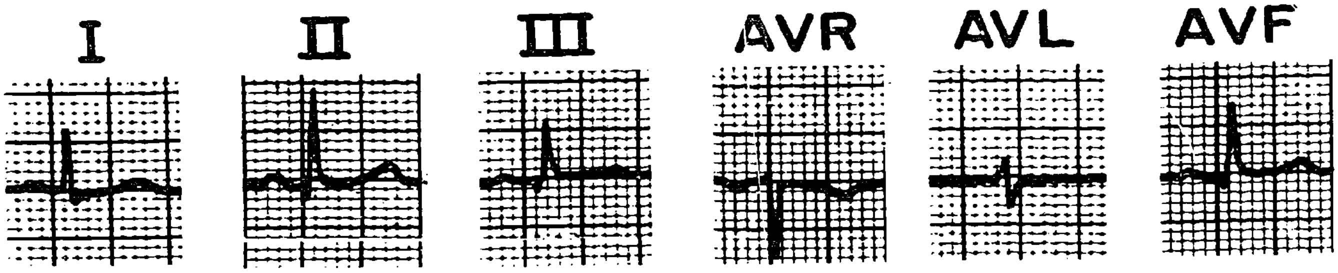


Figure 75

The perpendicular to the axis of lead AVL (Figure 76) is +60° or −120°. The mean frontal QRS vector in this electrocardiogram, therefore, must be located either at +60° or at −120°.

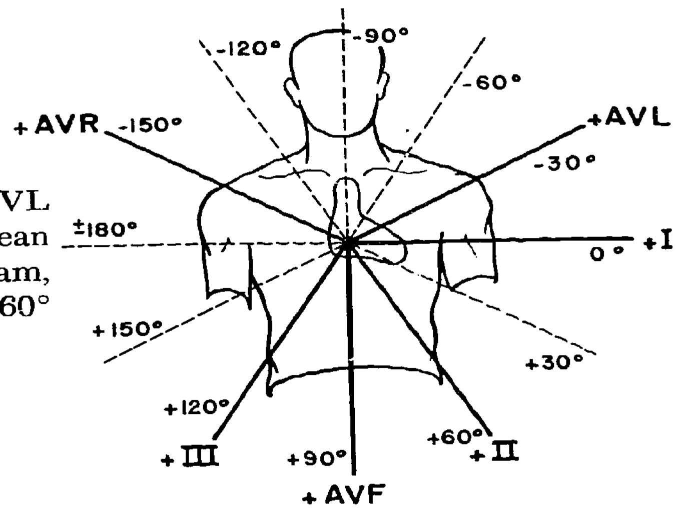


Figure 76 FRONTAL PLANE

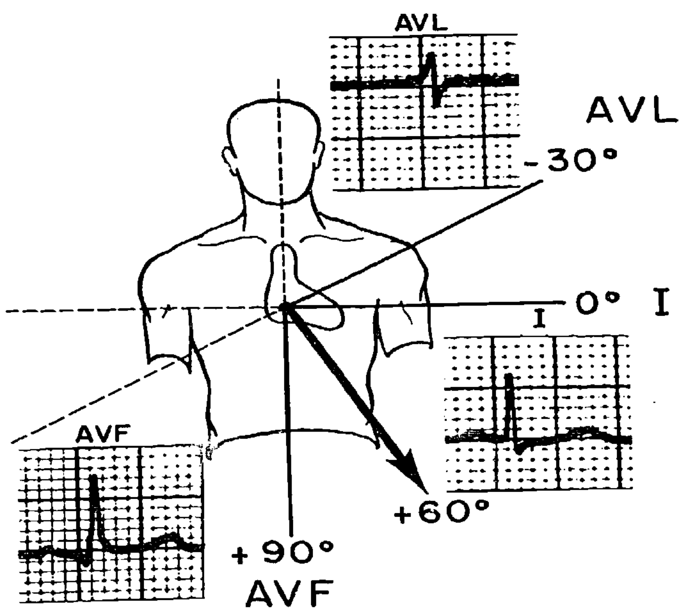


Figure 77

Since the quadrant rule preselected the left and inferior quadrant the mean frontal QRS vector is *left and inferior at +60°* (Figure 77).

4. MEAN FRONTAL QRS VECTOR
(Example 2)

4.1 *Net QRS Forces Along the Left-Right Axis*

The mean frontal QRS vector may be localized in space using *the Quadrant and Perpendicular Rules of Spatial Analysis.* Bipolar and unipolar leads from an electrocardiogram are presented in Figure 78.

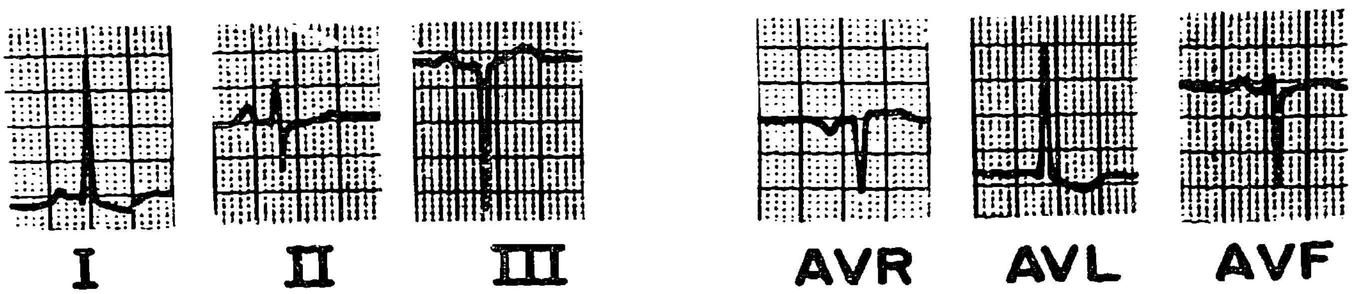


Figure 78

The predominant upright deflection in lead I indicates net QRS forces are moving toward the positive electrode of this lead. Since the positive electrode of lead I is located on the left arm QRS forces must be *left* (Figure 79).

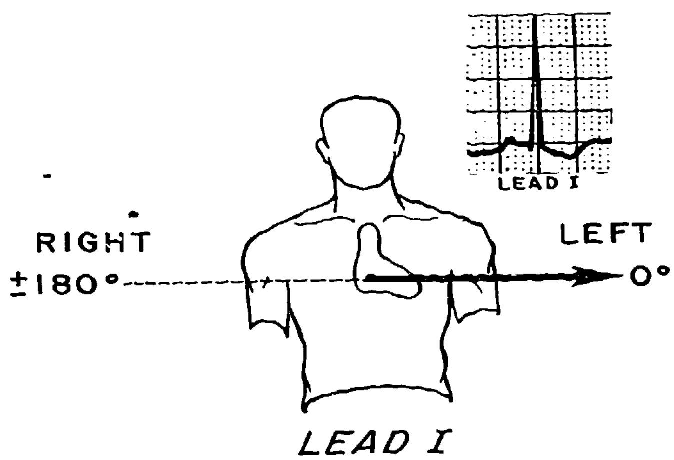


Figure 79

A rightward QRS vector requires QRS forces moving away from the positive electrode of lead I. QRS forces moving away from the positive electrode of lead I must give rise to a predominant negative deflection in this lead (Figure 80). The QRS complex in lead I is not a predominant negative deflection.

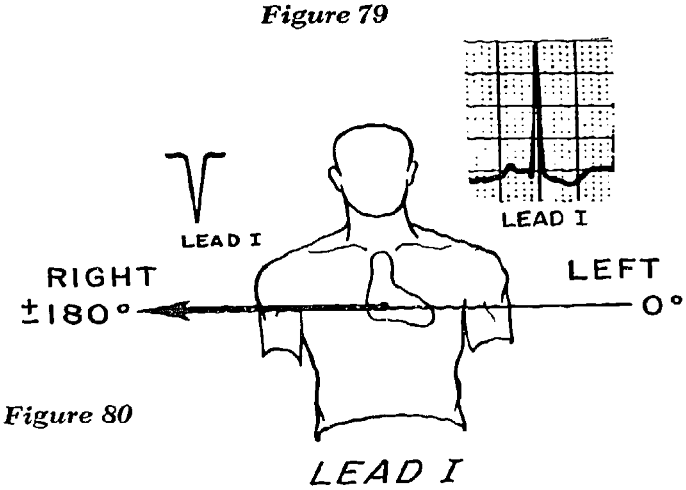


Figure 80

4.2 *Net QRS Forces Along the Superior-Inferior Axis*

Lead AVF in this tracing (Figure 78) presents a small upright deflection followed by a much larger negative deflection; this results in a net negative QRS complex.

A predominant negative deflection in lead AVF indicates net QRS forces are moving away from the positive electrode. Since the positive electrode of lead AVF is inferior, forces moving away from this electrode must be superior (Figure 81).

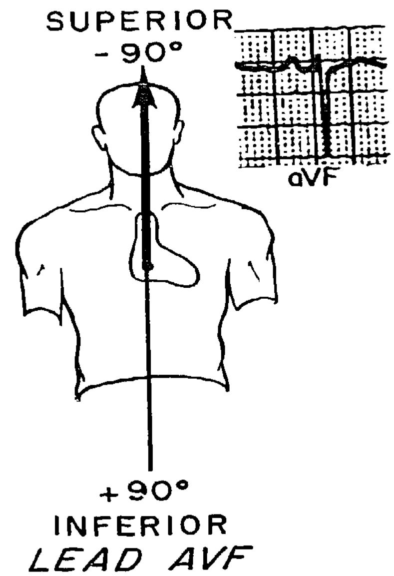


Figure 81

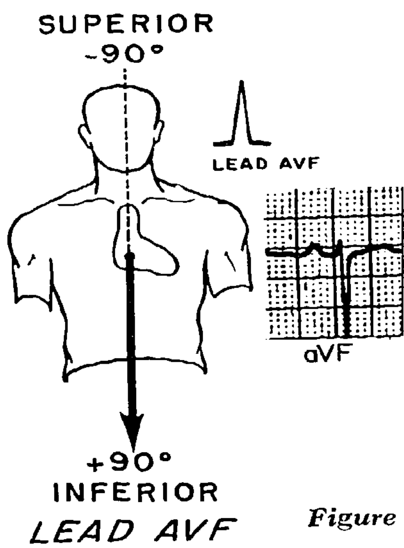


Figure 82

An inferior QRS vector demands QRS forces moving toward the positive electrode of lead AVF (Figure 82). QRS forces moving toward the positive electrode must give rise to a predominant upright QRS complex. The QRS complex in lead AVF of this tracing (Figure 78) is not a predominant upright deflection.

4.3 *Mean Frontal QRS Vector-Quadrant Rule*

The upright deflection in lead I of this tracing (Figure 78) indicates net QRS forces are left; the predominant negative deflection in lead AVF indicates net QRS forces are superior. This localizes mean frontal QRS vector to the *left and superior quadrant* (Figure 83).

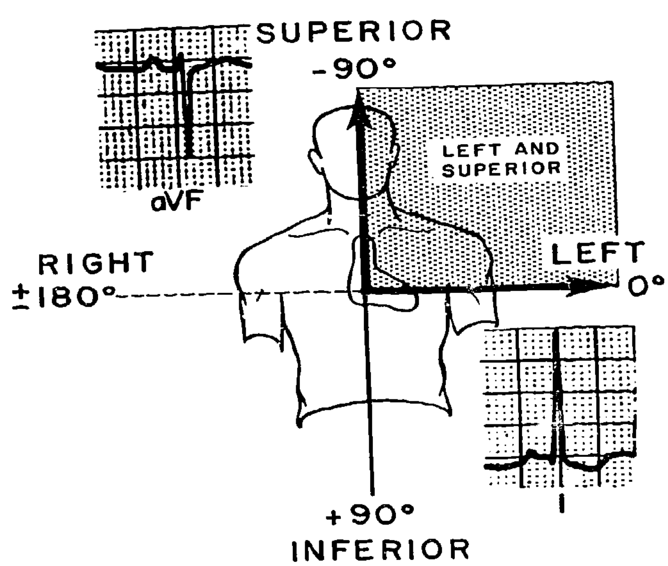


Figure 83

4.4. *Mean Frontal QRS Vector—Perpendicular Rule*

The mean frontal QRS vector may be localized in degrees by the Perpendicular Rule of Spatial Analysis. This rule states the mean QRS vector is perpendicular to the axis of the lead with the equiphasic complex. Lead II of this tracing (Figure 84) displays an equiphasic QRS complex.

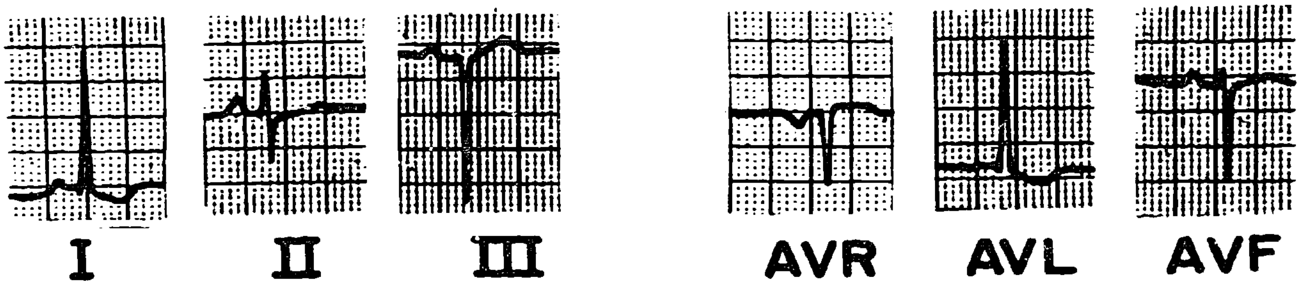


Figure 84

The perpendicular to the axis of lead II lies along the —30° to +150° axis (Figure 85).

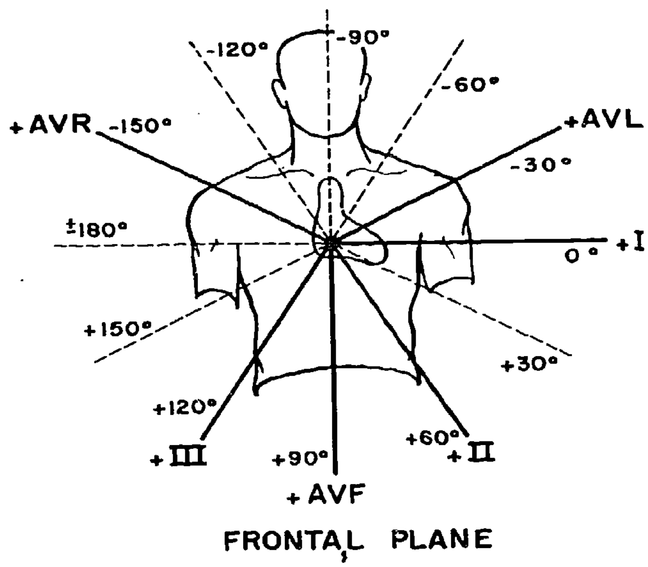


Figure 85

The mean frontal QRS vector, therefore, must be located in the preselected left and superior quadrant, at —30° (Figure 86).

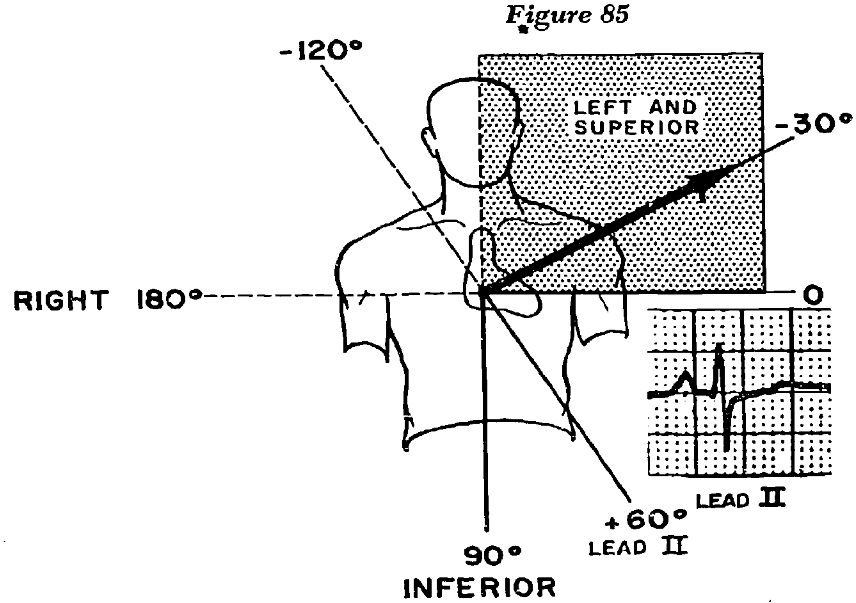


Figure 86

5. SUMMARY

The Introduction to Spatial Analysis has emphasized the following points:

a. An upright deflection, an R wave, in any lead represents QRS forces moving toward the positive electrode of that lead.

b. The two principle axes of the frontal plane may be represented best by lead I for the left-right axis and lead AVF for the superior-inferior axis. An upright deflection, therefore, must represent leftward QRS forces in lead I and inferior QRS forces in lead AVF.

c. The mean frontal QRS vector may be localized with the *Quadrant Rule of Spatial Analysis* by combining QRS vectors from the left-right and superior-inferior leads.

d. The mean frontal QRS vector may be fixed more precisely in degrees with the *Perpendicular Rule of Spatial Analysis*. This rule states the mean QRS vector is perpendicular to the axis of the lead with the equiphasic QRS complex and in the predetermined quadrant.

6. MEAN FRONTAL QRS VECTOR

(Example 3)

6.1 *Quadrant Rule*

The frontal plane leads from an electrocardiogram are presented below (Figure 87).

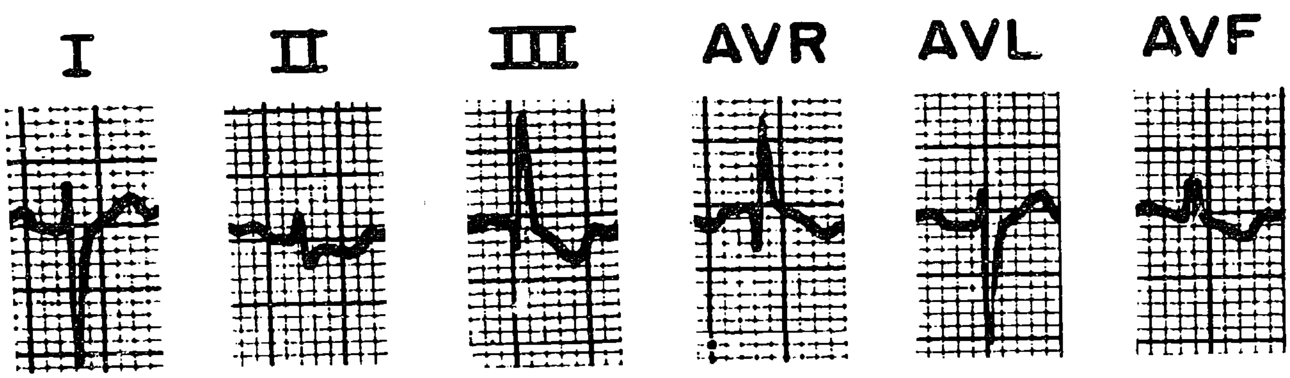


Figure 87

The predominant negative deflection in lead I indicates net QRS are *right;* the predominant upright deflection in lead AVF indicates net QRS forces are *inferior*. The mean frontal QRS vector in this tracing, therefore, is localized *right and inferior* (Figure 88).

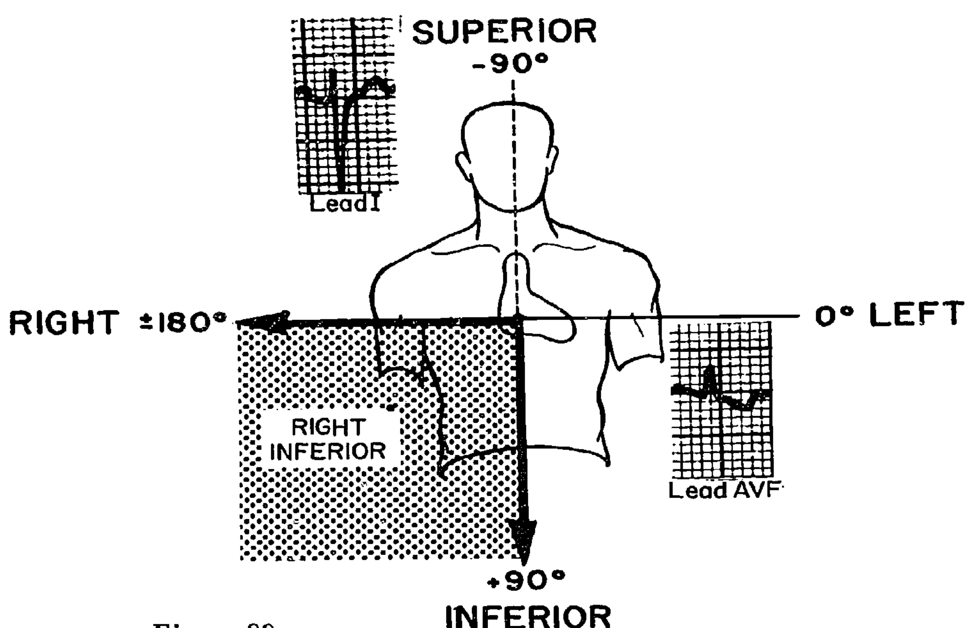


Figure 88

6.2 Perpendicular Rule

The equiphasic QRS complex is located in lead II; the mean frontal QRS vector then must lie along the −30° to +150° axis (Figure 89).

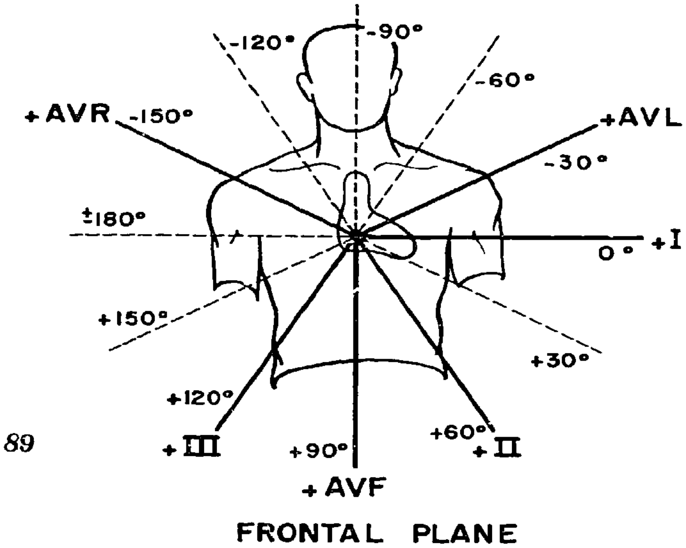


Figure 89

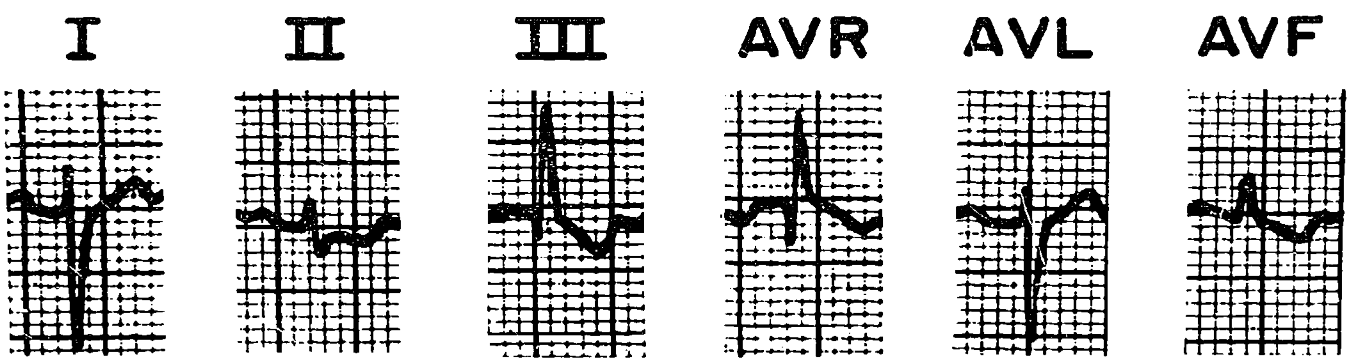


Figure 90

Since only the +150° axis is located in the preselected right and inferior quadrant (Figure 91), the mean frontal QRS vector in this tracing is right and inferior at +150°.

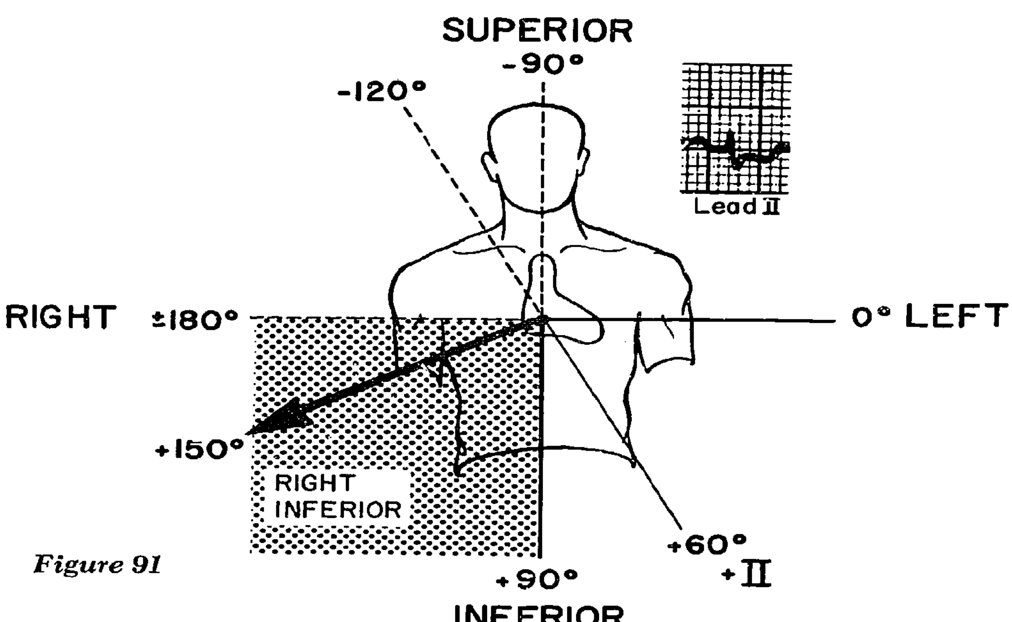


Figure 91

7. Example 4

7.1 *Quadrant and Perpendicular Rules*

Frontal plane leads from an electrocardiogram are presented below in Figure 92.

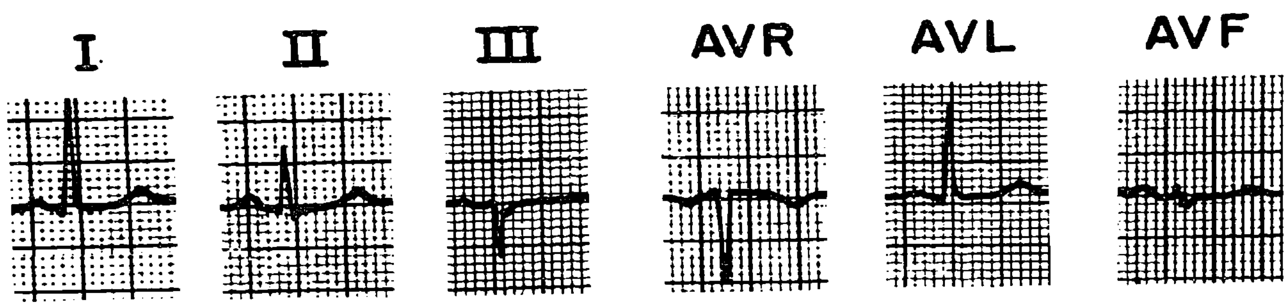


***Figure* 92**

The upright deflection in lead I indicates net QRS forces are *left*. The equiphasic QRS complex in lead AVF locates the mean QRS vector perpendicular to the axis of lead AVF, i.e., *at 0°*. The mean frontal QRS vector, therefore, is *left and neither superior nor inferior* (Figure 93).

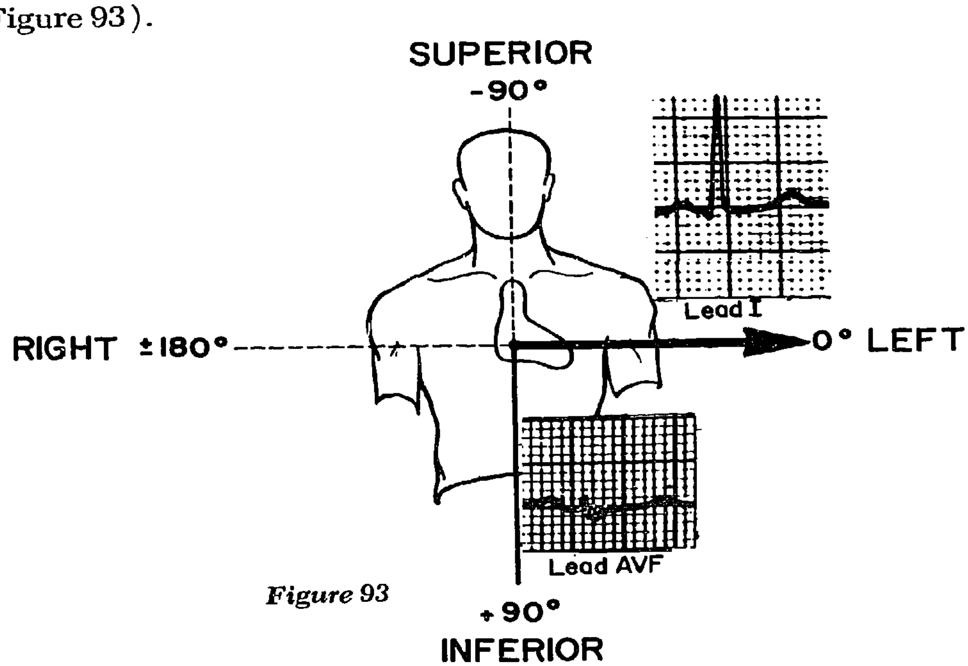


***Figure* 93**

8. Example 5

8.1 *Quadrant Rule*

In the frontal plane leads from an electrocardiogram (Figure 94), the large upright deflection in lead I indicates net QRS forces are *left* (Figure 95); the predominant negative deflection in lead AVF indicates net QRS forces are *superior*. The mean frontal QRS vector in this tracing, then, lies in the *left and superior quadrant*.

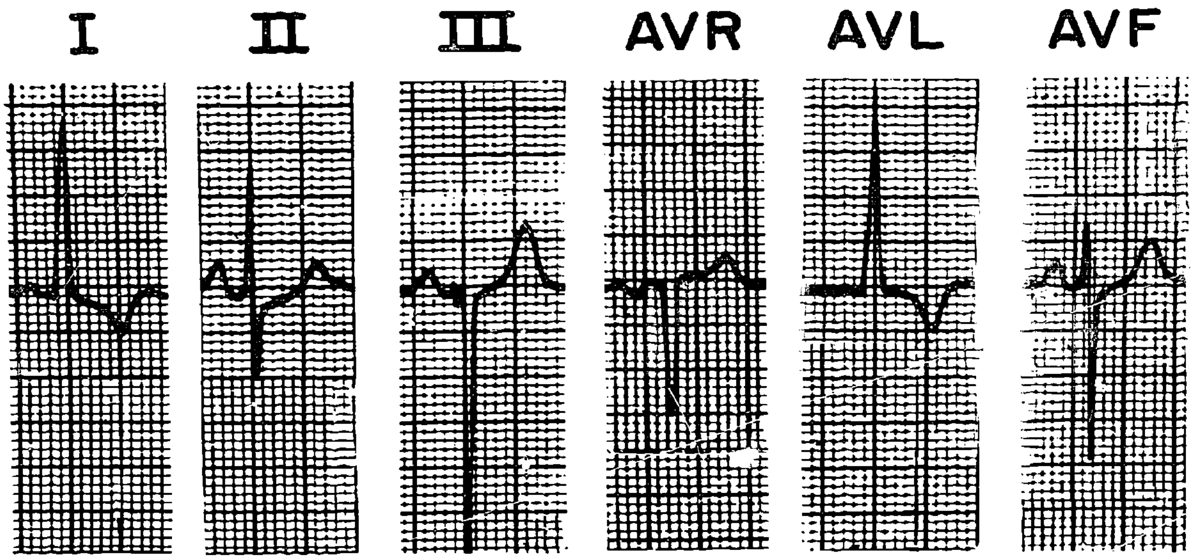


Figure 94

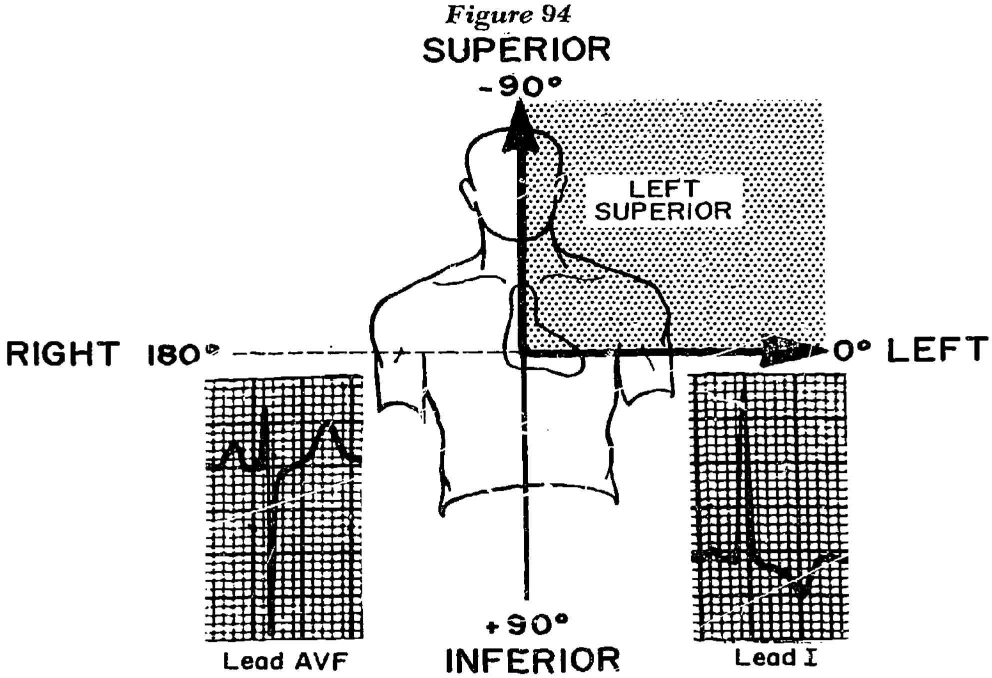


Figure 95

8.2 *Perpendicular Rule*

The lead displaying the most nearly equiphasic QRS complex (Figure 94) is lead II. The perpendicular to the axis of lead II (Figure 94) in the preselected left and superior quadrant is —30° (Figure 96). Note, however, the upright deflection in lead II is slightly larger than the negative deflection. This indicates the mean frontal QRS vector is inclined slightly away from the perpendicular *into the positive field of lead II*. Since the positive field of lead II is oriented toward the left leg, the mean frontal QRS vector in this tracing must be inclined slightly more inferior than —30°, to approximately —20° (Figure 96).

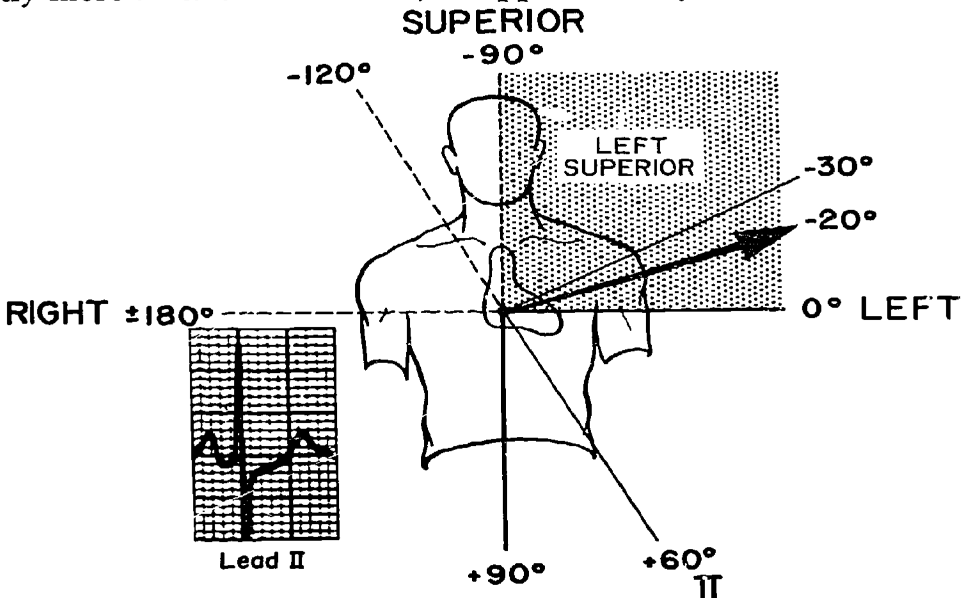


Figure 96

If the QRS complex of lead II were slightly more negative than positive, the mean frontal QRS vector would be localized slightly into the negative field of lead II, to approximately —40° (Figure 97).

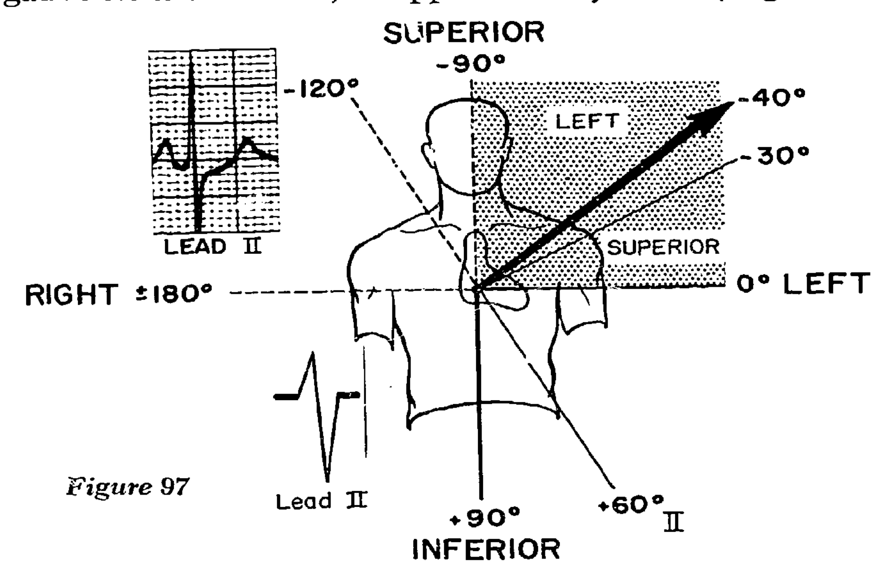


Figure 97

Section III

MEAN HORIZONTAL QRS VECTOR

1. Introduction

Unipolar chest leads V_1 through V_6 are located on the anterior and lateral aspects of the chest (Figure 98). These locations represent the positive electrodes of the chest leads. The negative electrode for these leads is a central terminal assumed to be located within the heart.

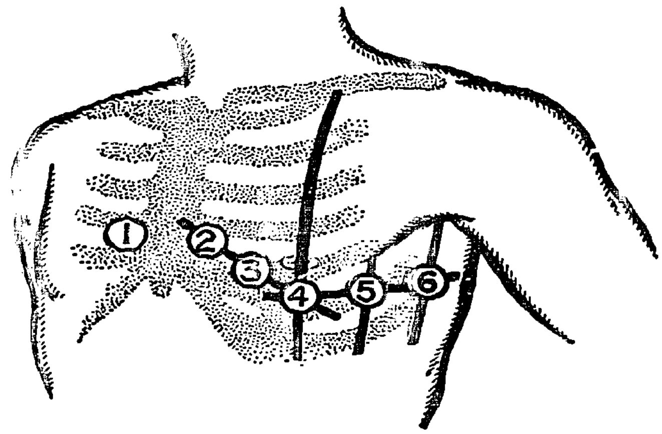


Figure 98

The locations of these electrodes define the horizontal plane through the heart at the level of the fifth innerspace. Chest leads, therefore, lie in the horizontal plane of the body. The horizontal plane (Figure 99) divides the body into upper and a lower half and is defined by the left-right and anterior-posterior axes. The frontal plane divides the body into a front and back half and is defined by the left-right and superior-inferior axes.

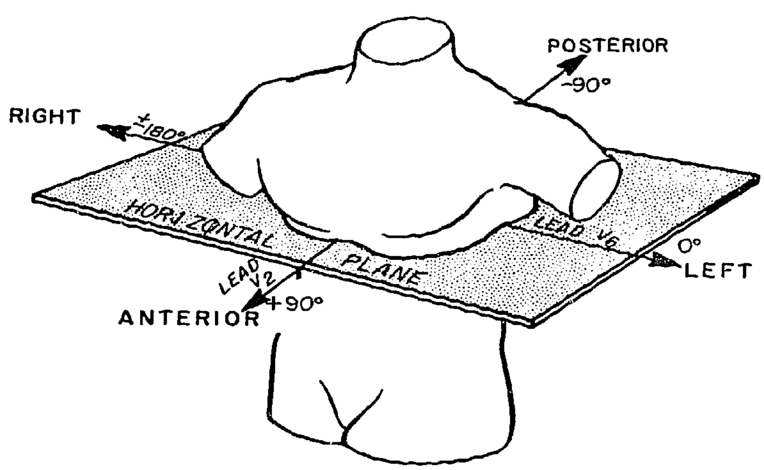


Figure 99

1.1 *Horizontal Plane Reference Figure*

The positive electrodes of leads V_1 through V_6 may be located on a diagram representing a transverse section through the heart at the level of the fifth innerspace (Figure 100). The axes of these chest leads in degrees also may be added. The negative portion of each lead axis lies 180° opposite its positive portion. The resulting figure is known as the *Horizontal Plane Reference Figure*.

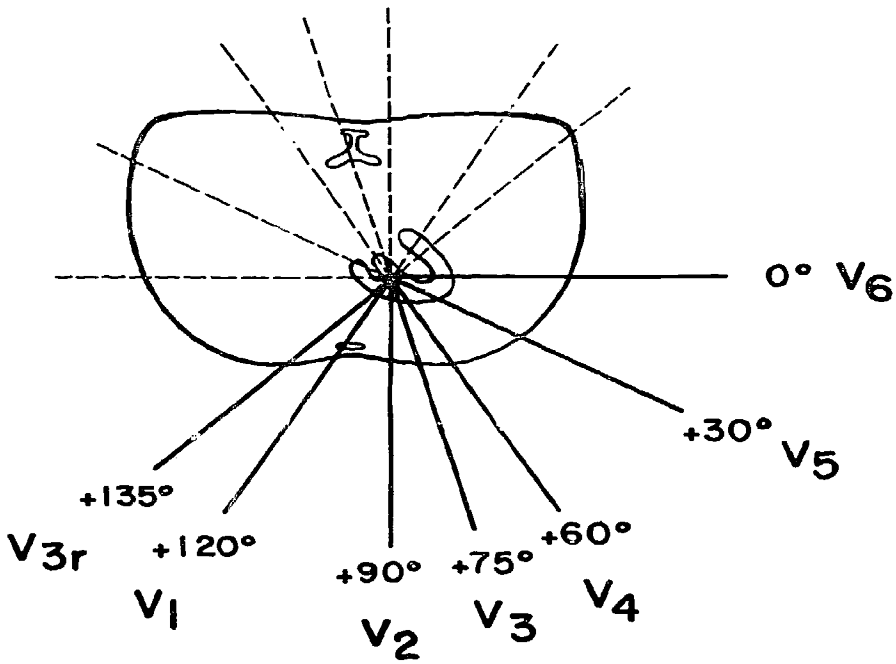


Figure 100

1.2 *Best Horizontal Left-Right Lead*

The Horizontal Plane Reference Figure illustrates the chest leads, the locations of the positive electrodes, and the axes of each lead in degrees. Utilizing this reference figure (Figure 100), it is possible to select the leads best representing left-right voltage changes in the horizontal plane.

The best left-right lead in the horizontal plane is lead V_6. The Horizontal Plane Reference Figure indicates the positive portion of the lead V_6 axis is 0°. Lead V_6, therefore, is a "pure" left-right lead without anterior-posterior tilt (Figure 101).

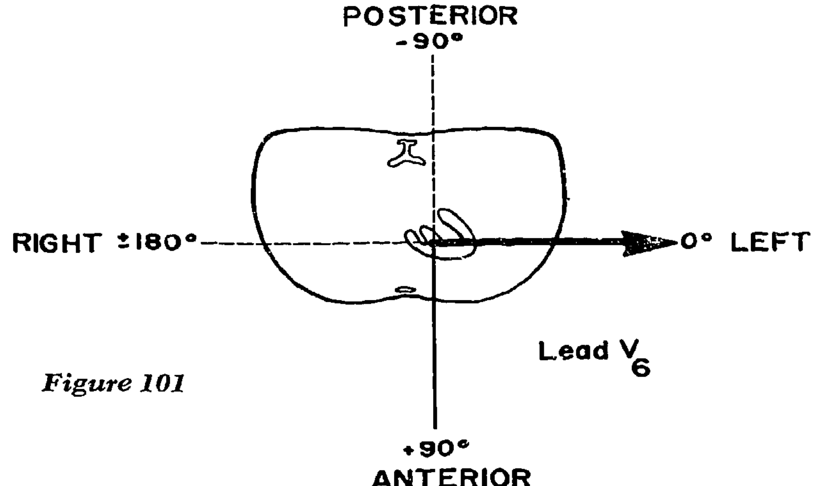


Figure 101

Lead V_6 is the best left-right lead in the horizontal plane. Lead I is the best left-right lead in the frontal plane. For spatial analysis, however, either lead V_6 or lead I may be utilized as a left-right lead, provided both leads are similar in configuration. If leads I and V_6 are dissimilar, it is best to utilize lead I, since this is a more "distant" lead and therefore is not subject to errors in electrode positioning.

1.3 *Best Anterior-Posterior Lead*

Utilizing the Horizontal Plane Reference Figure (Figure 102), it is possible to select the horizontal lead best representing anterior-posterior voltage changes. The lead best representing voltage changes along the anterior-posterior axis is lead V_2. The positive portion of the lead V_2 axis is anterior at $-90°$. Lead V_2, therefore, is a "pure" anterior-posterior lead without left-right tilt (Figure 103).

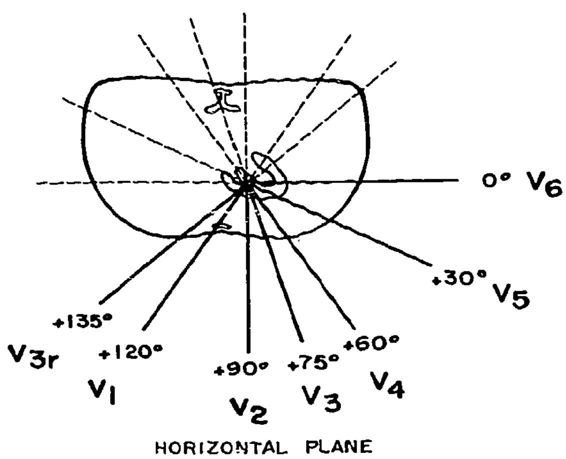


Figure 102

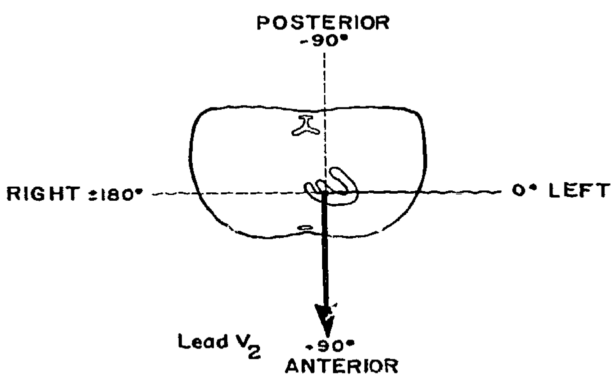


Figure 103

The positive portion of the lead V_1 axis is located anterior and slightly rightward at $+120°$ (Figure 104). Lead V_1 often is identical in configuration to lead V_2; lead V_1, therefore, may be used as an anterior-posterior lead. Should lead V_1 and lead V_2 differ, lead V_1 may be more accurate as an anterior-posterior lead. Experience only can dictate which lead is the more appropriate anterior-posterior lead.

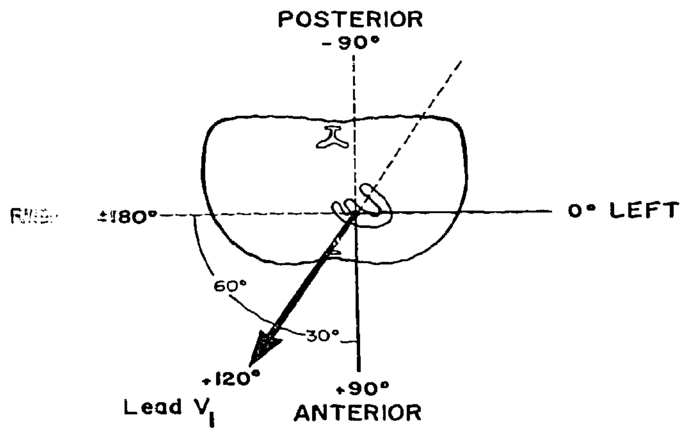


Figure 104

1.4 *Best Horizontal Leads*

The mean horizontal QRS vector may be located by combining net QRS forces from the left-right and anterior-posterior leads (Figure 105). The best horizontal plane leads to determine the mean horizontal QRS vector are leads V_2 and V_6.

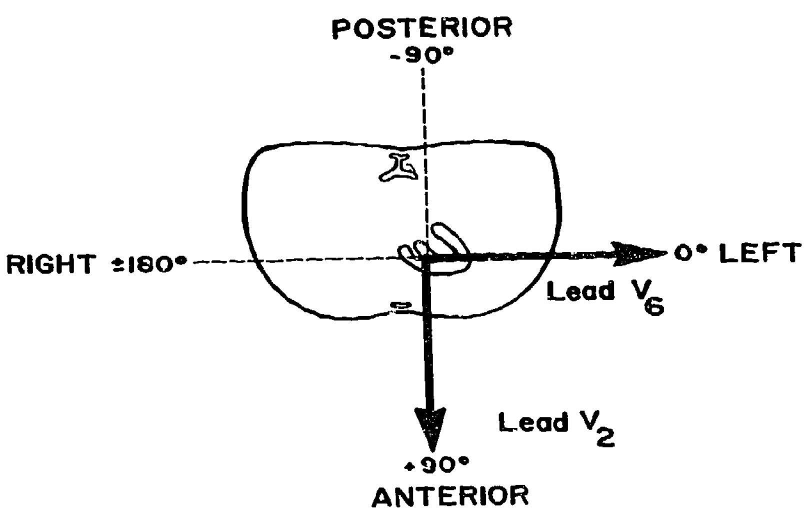


Figure 105

The positive portion of the lead V_2 axis is anterior at $+90°$; the positive portion of the lead V_6 axis is left at $0°$. These leads represent "pure" anterior-posterior and left-right leads, respectively. Combining net QRS forces in these leads will localize the mean horizontal QRS vector to a quadrant (Figure 106).

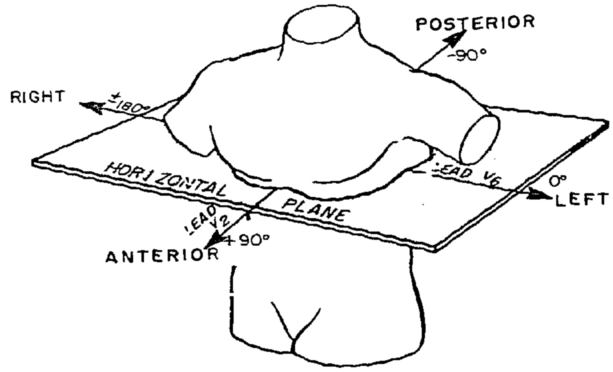


Figure 106

2. MEAN HORIZONTAL QRS VECTOR (Example 6)

2.1 *Quadrant Rule*

The mean horizontal QRS vector may be determined similar to the mean frontal QRS vector with the Quadrant and Perpendicular Rules of Spatial Analysis. In the horizontal plane leads from an electrocardiogram (Figure 107), the predominant upright QRS deflection in lead V_6 indicates net QRS forces are *left* (Figure 108).

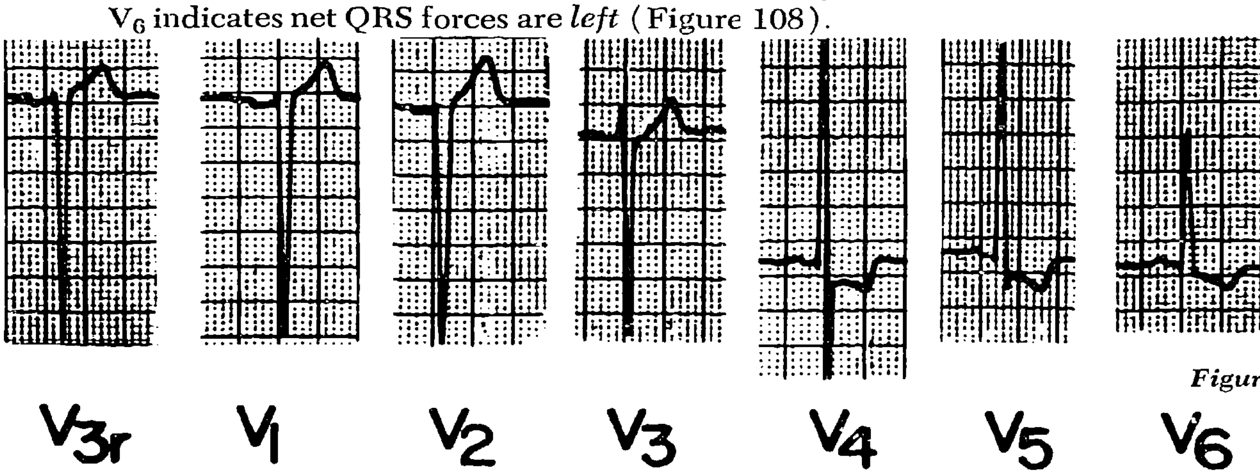
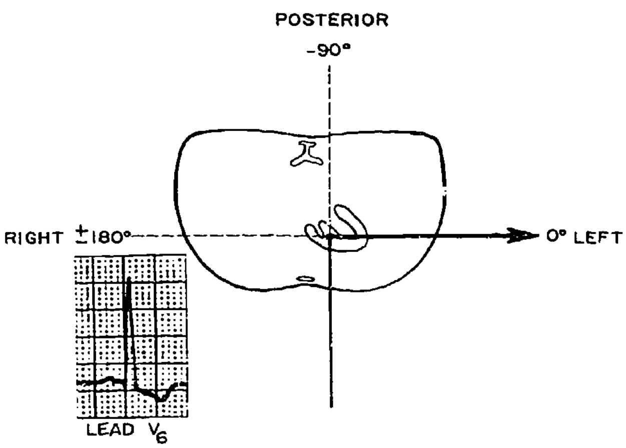


Figure 107

The predominant negative QRS deflection in lead V_2 indicates net QRS forces are *posterior* (Figure 109).



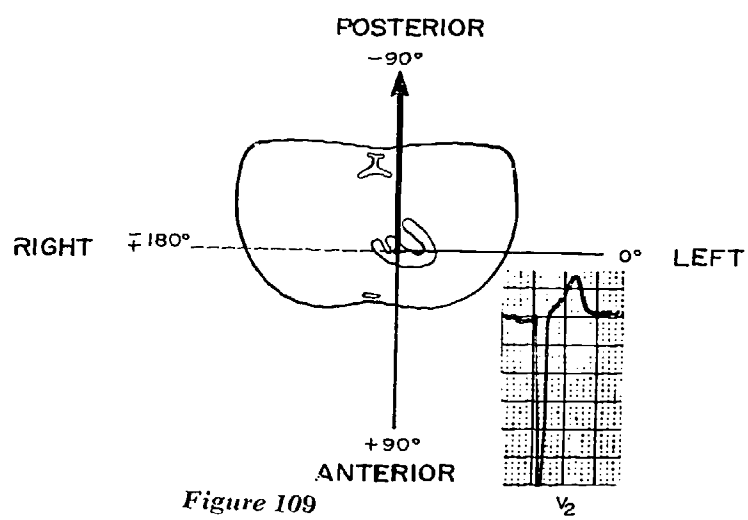


Figure 109

Combining the net directions of QRS forces in these two leads localizes the mean horizontal QRS vector to a quadrant. The mean horizontal QRS vector, therefore, is localized left and posterior (Figure 110).

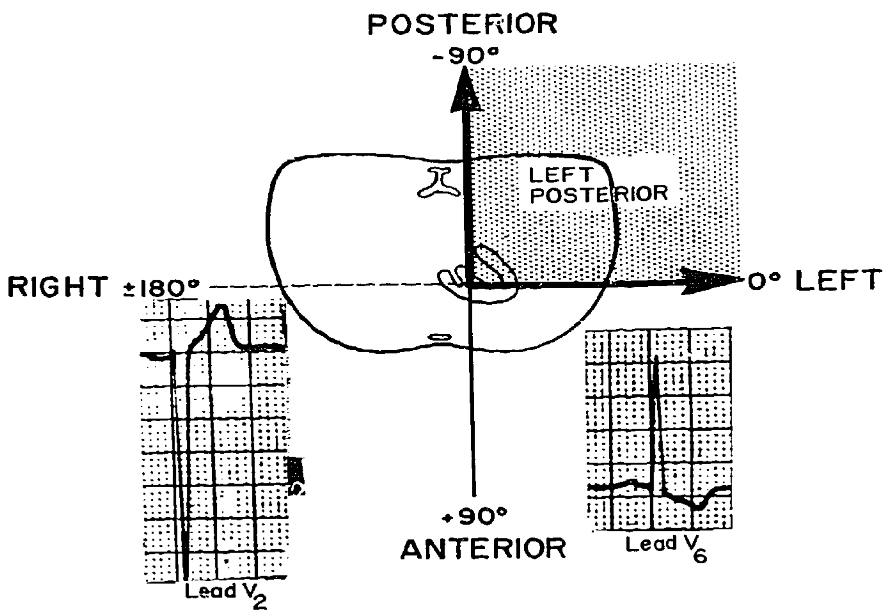


Figure 110

The mean horizontal QRS vector *cannot* be rightward (Figure 111), since net rightward QRS forces demand a predominant negative deflection in lead V_6. The mean horizontal QRS vector also *cannot* be anterior since this demands a predominant upright deflection in lead V_2.

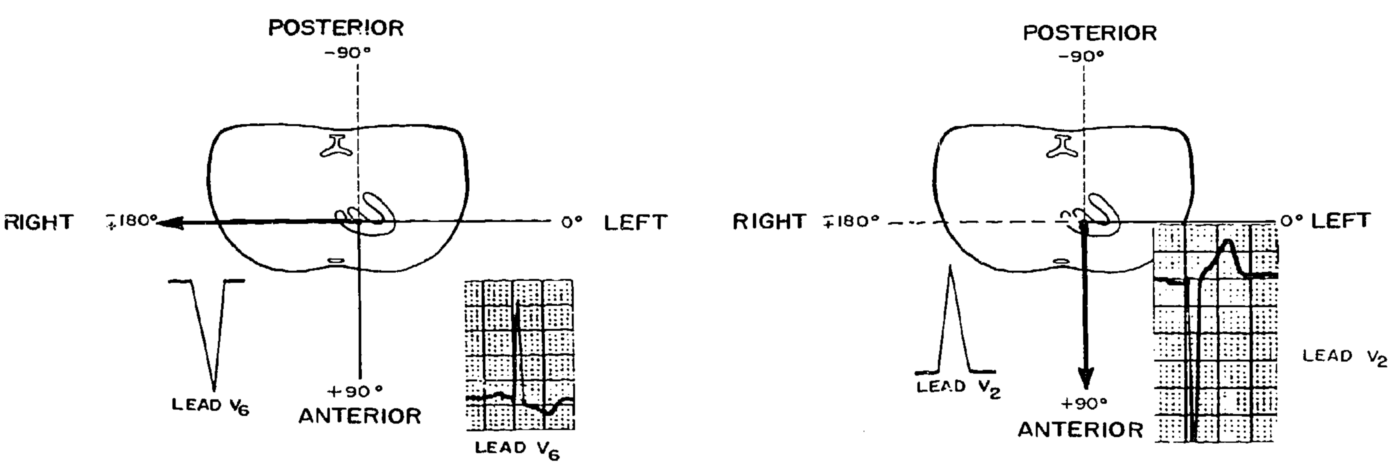


Figure 111

2.2 *Perpendicular Rule*

The mean horizontal QRS vector may be fixed in degrees utilizing the Perpendicular Rule of Spatial Analysis. Lead V_4 in this tracing (Figure 112) presents an equiphasic QRS complex. The mean horizontal QRS vector, therefore, must lie perpendicular to the axis of lead V_4 (Figure 113), in the preselected left and posterior quadrant, at $-30°$ (Figure 114).

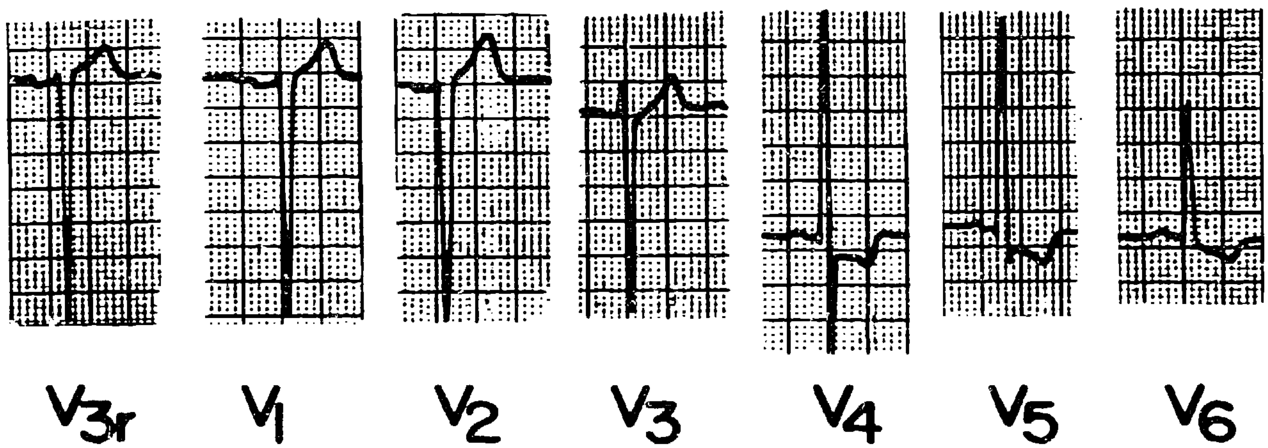


Figure 112

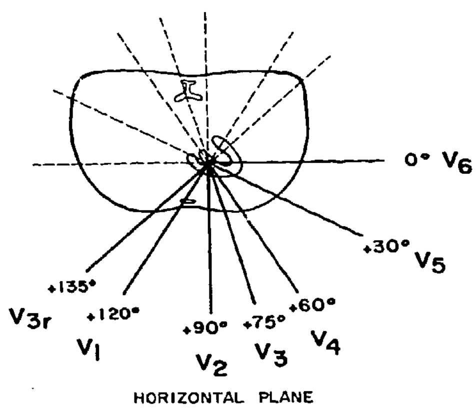


Figure 113

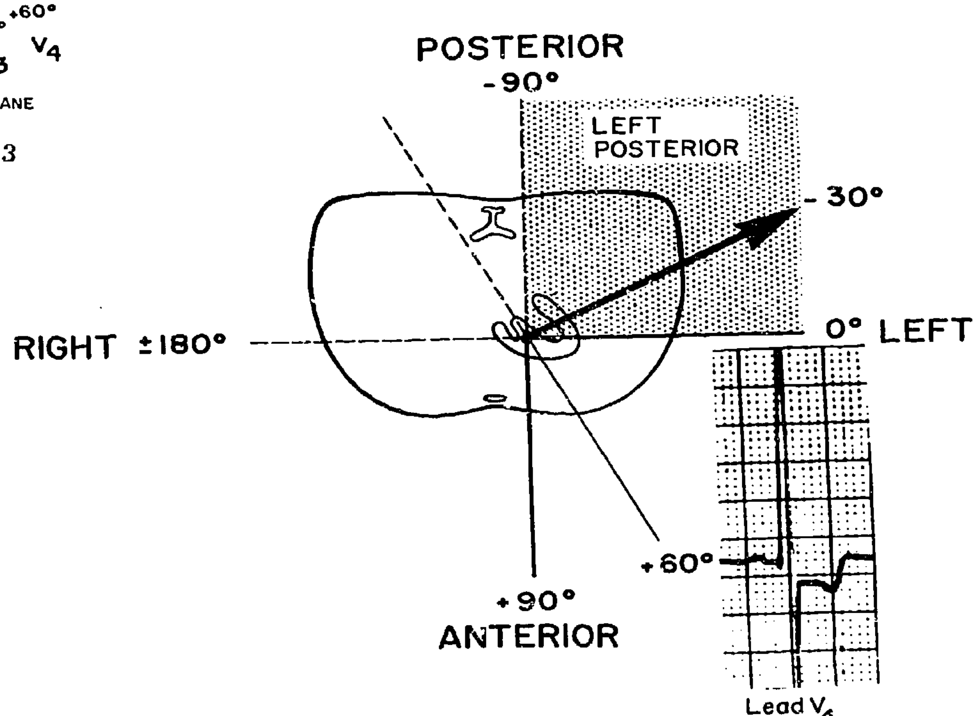


Figure 114

The mean horizontal QRS vector *cannot* be located at —15° (Figure 115) since this demands an equiphasic QRS complex in lead V_3.

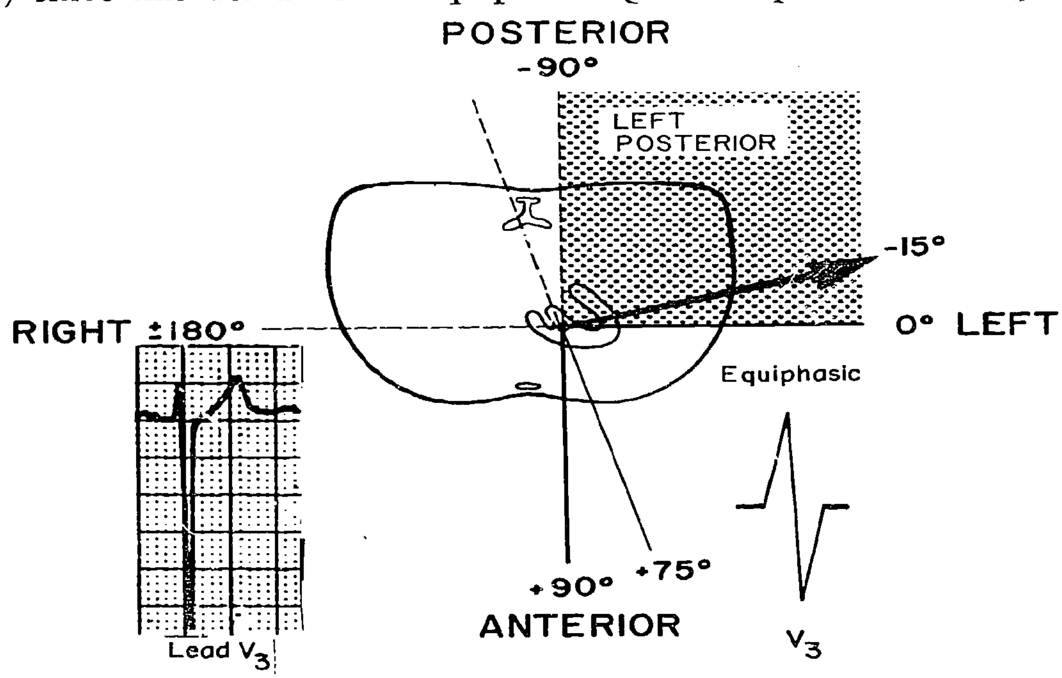


Figure 115

The mean horizontal QRS vector also cannot be located at —60° (Figure 116) since this demands an equiphasic QRS complex in lead V_5.

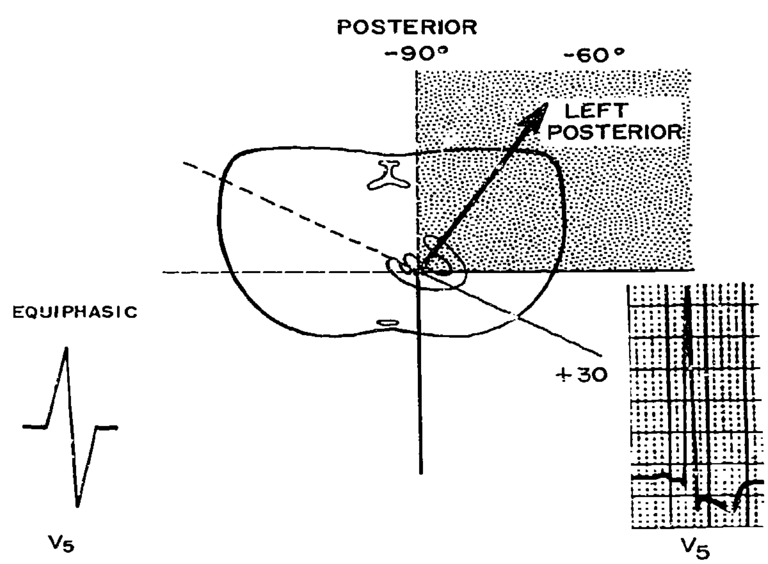


Figure 116

3. MEAN HORIZONTAL QRS VECTOR

(Example 7)

3.1 *Quadrant Rule*

In the horizontal plane leads (Figure 117), the predominant upright QRS deflection in lead V_6 indicates net QRS forces are *left*. The predominant negative QRS deflection in lead V_2 indicates net QRS forces are *posterior*.

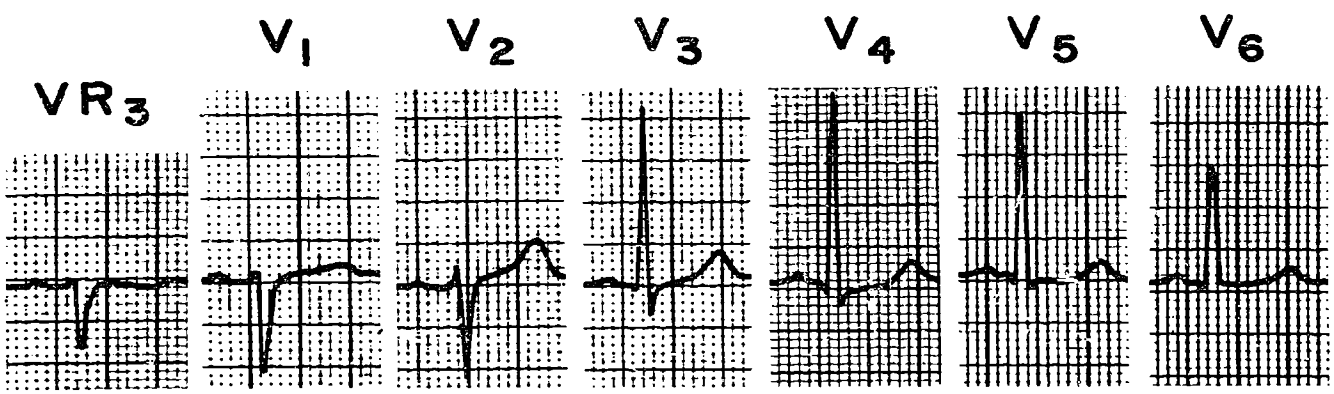


Figure 117

The mean horizontal QRS vector (Figure 118) according to the quadrant rule, is *left and posterior*.

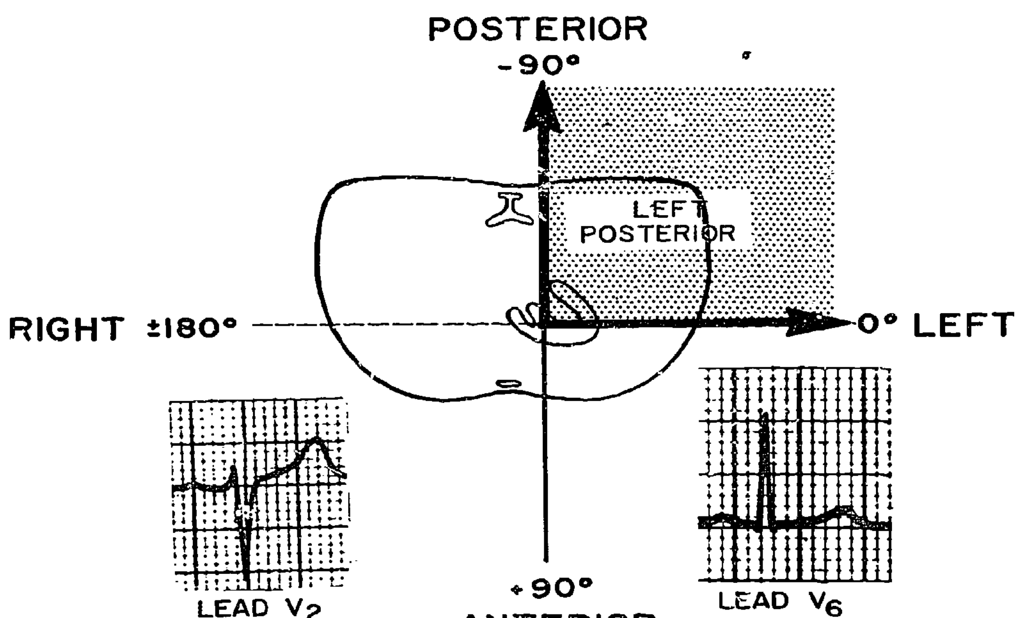


Figure 118

3.2 *Perpendicular Rule*

The mean horizontal QRS vector may be fixed in degrees with the Perpendicular Rule of Spatial Analysis. The mean QRS vector lies perpendicular to the axis of the lead with the equiphasic QRS complex and in the preselected quadrant. Occasionally tracings are obtained in which an *equiphasic QRS complex is not observed*. It is necessary, then, to approximate the location and axis of the lead in which the equiphasic complex would be anticipated.

An equiphasic QRS complex is not apparent in the horizontal plane leads displayed below (Figure 119). Since the QRS complex in lead V_2 is predominantly negative and the QRS complex in lead V_3 is predominantly positive, the lead with the equiphasic QRS complex must be located between these leads.

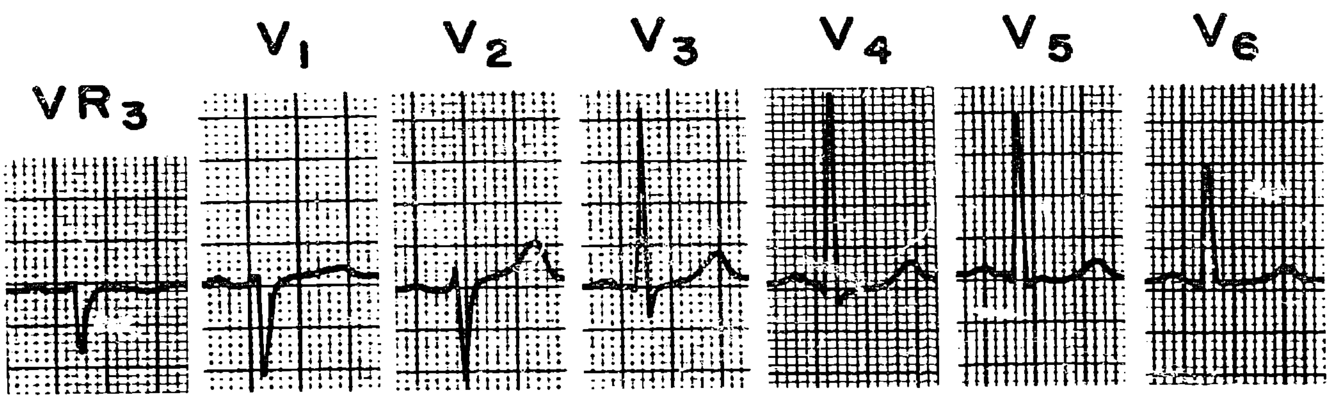
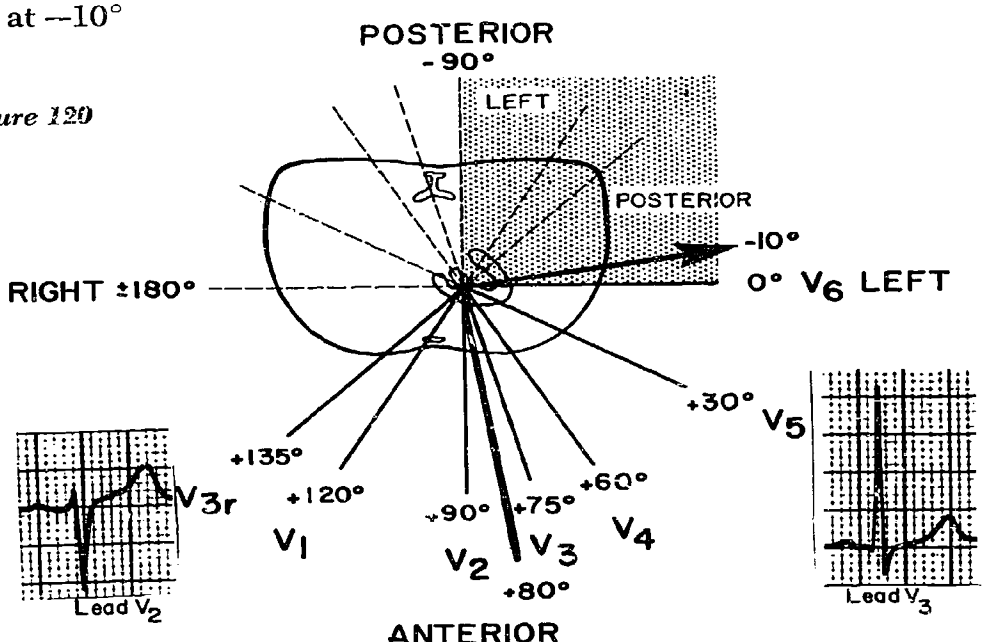


Figure 119

The diagram (Figure 120) indicates the positive axis of lead V_2 is at $+90°$ and the positive axis of lead V_3 is at $+75°$. The positive axis of the lead lying between leads V_2 and V_3, therefore, is approximately $+80°$. The mean horizontal QRS vector, then, must lie in the preselected left and posterior quadrant, perpendicular to the $+80°$ axis, at $-10°$

Figure 120



The mean horizontal QRS vector *cannot* be located at 0° (Figure 121) since this demands an equiphasic QRS complex in lead V_2.

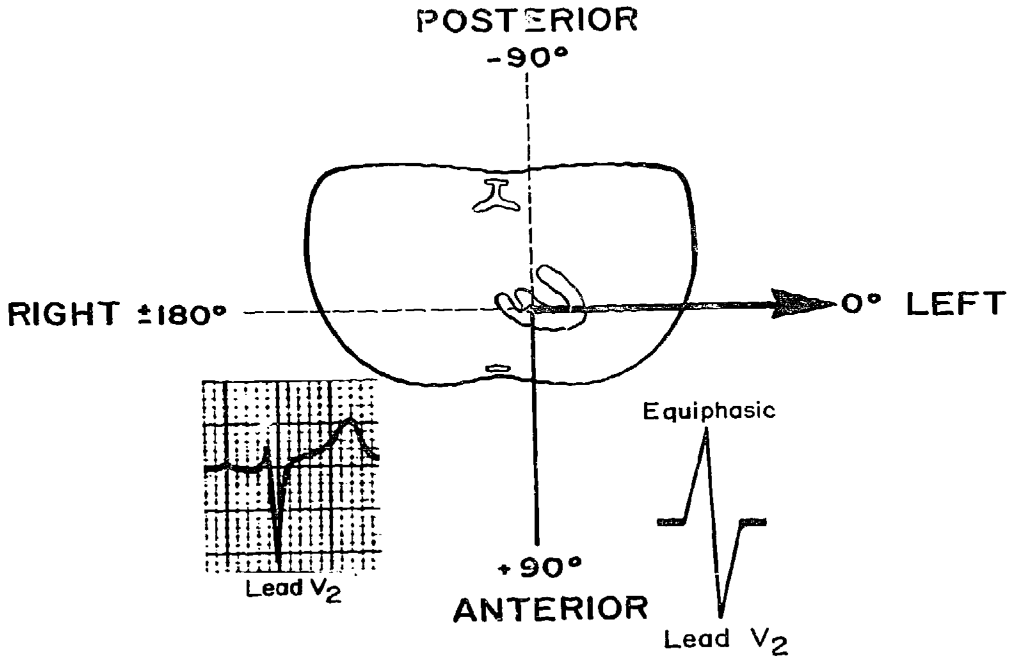


Figure 121

The mean horizontal QRS vector also *cannot* be located at −15° (Figure 122), since this requires an equiphasic QRS complex in lead V_3.

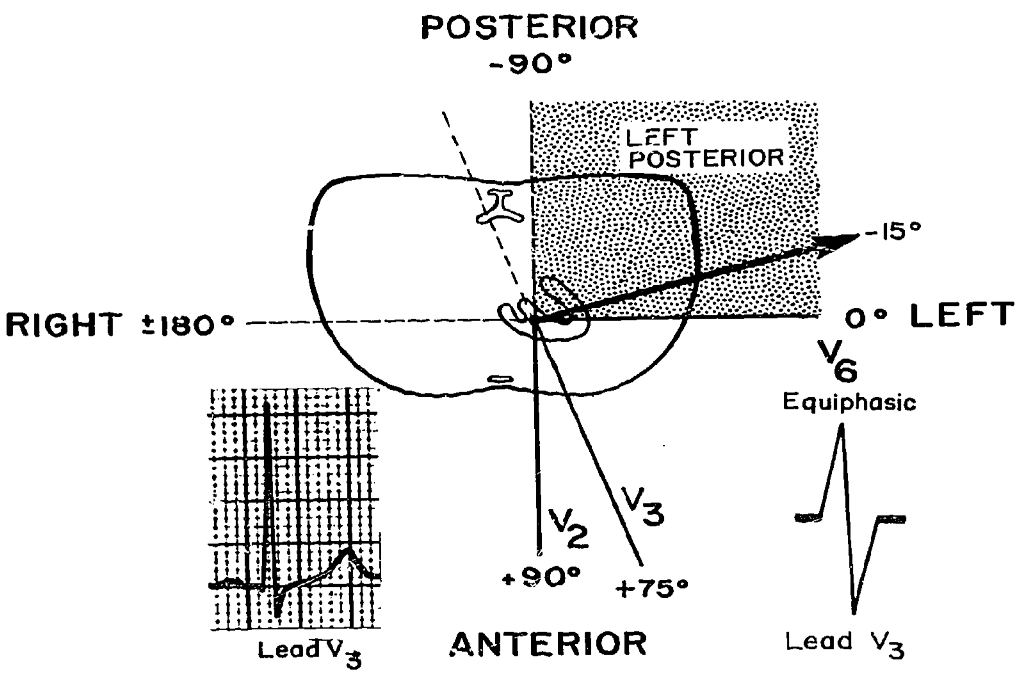


Figure 122

4. MEAN T VECTOR

4.1 *Mean Frontal T Vector-Quadrant Rule*—(Example 8)

Mean T vectors may be determined similar to the mean QRS vector by the Quadrant and Perpendicular Rules of Spatial Analysis. In the frontal plane leads below (Figure 123), the predominant upright T waves in leads I and AVF indicate the mean frontal T vector lies *left* and *inferior* (Figure 124).

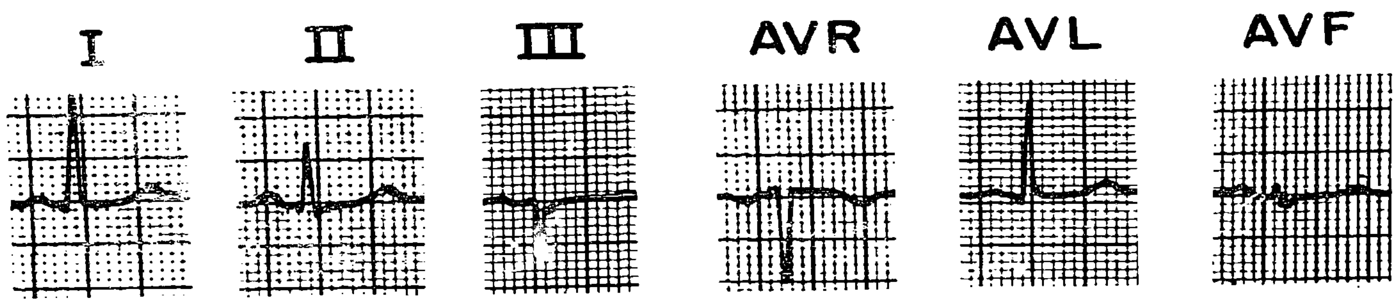


Figure 123

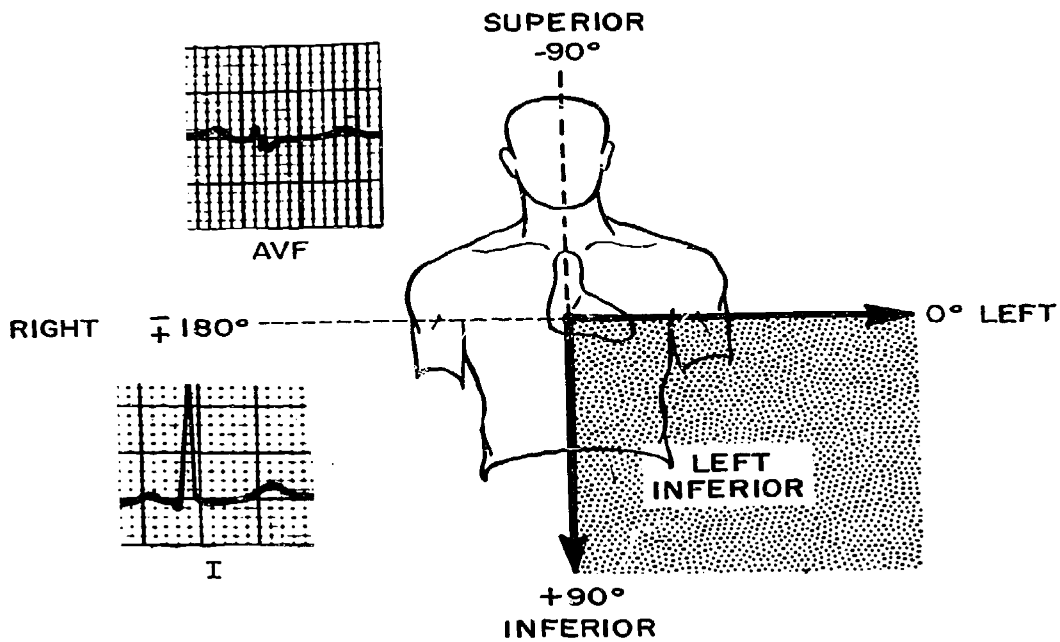


Figure 124

4.2. *Mean Frontal T Vector-Perpendicular Rule*—(Example 8)

The Perpendicular Rule of Spatial Analysis also is used to locate the mean T vector in degrees. The mean frontal T vector (Figure 123) has been localized in the left and inferior quadrant.

The T wave in lead III is flat (a net area of zero) and hence is an equiphasic T wave. The mean T vector lies perpendicular to the axis of lead III in the preselected left and inferior quadrant, at +30° (Figure 124-a).

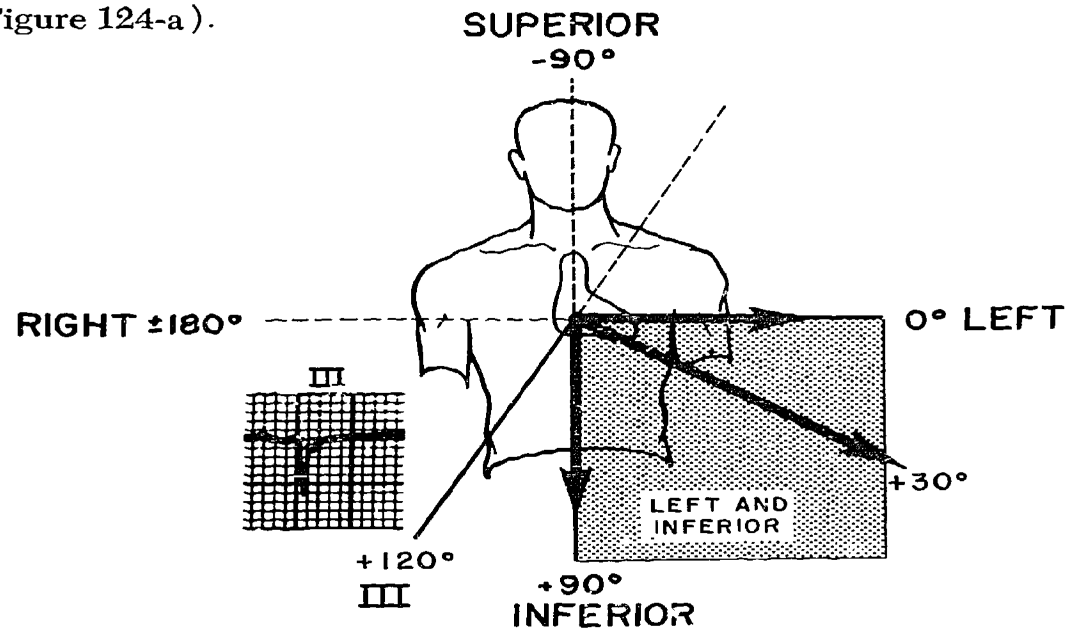


Figure 124-a

The mean frontal T vector *cannot* be located at +60° (Figure 125) since this demands an equiphasic or flattened T wave in lead AVL; lead AVL in this tracing contains an upright T wave.

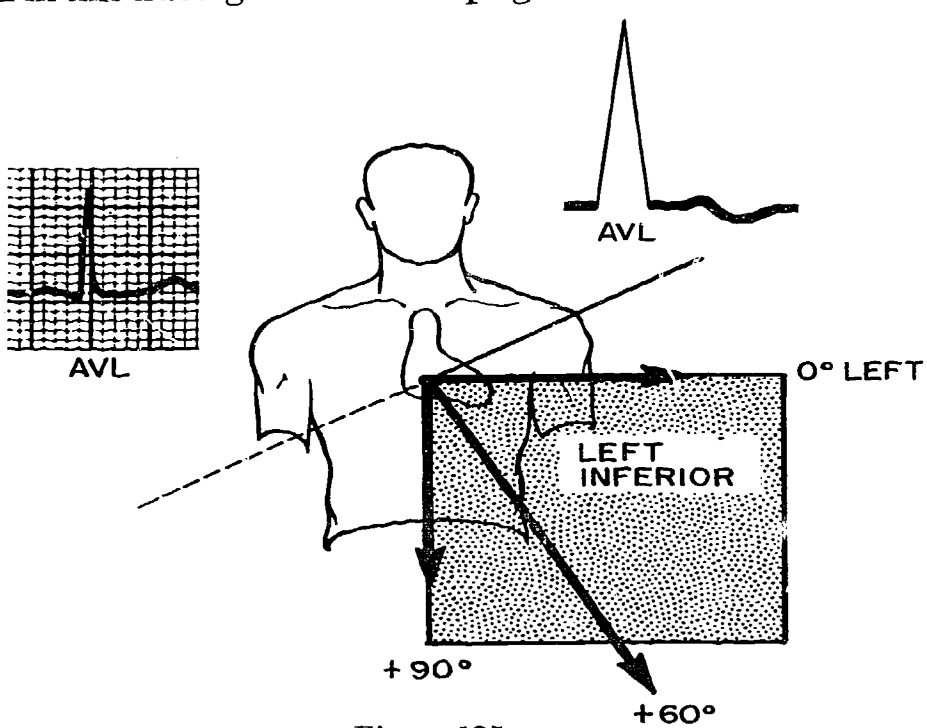


Figure 125

The mean frontal T vector also *cannot* be located at −150° (Figure 126). The perpendicular rule locates the mean T vector perpendicular to the axis of the lead with the equiphasic or flat T wave. A flat T wave is observed in lead III. A mean T vector at −150° is perpendicular to the axis of lead III but does *not* lie in the preselected left and inferior quadrant.

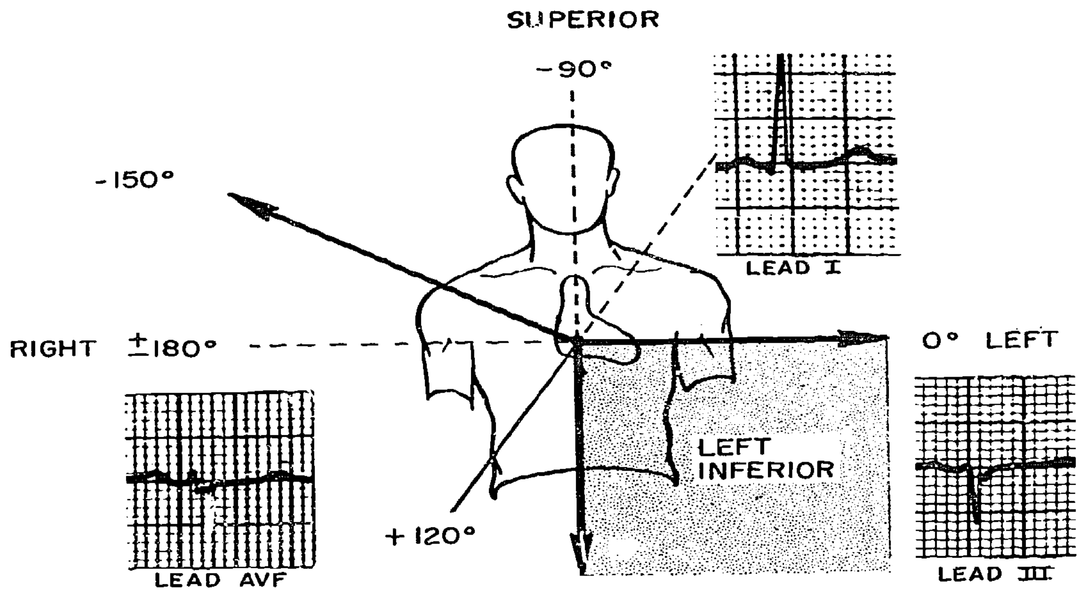


Figure 126

4.3. *Mean Horizontal T Vector*—(Example 9)

The upright T deflection in lead V_2 (Figure 127) indicates the mean T vector is *anterior;* the upright T deflection in lead V_6 indicates the mean T vector is *left*. The mean horizontal T vector, therefore, is *left and anterior* (Figure 128).

Because T waves often are small, to use the perpendicular rule, it is adequate to select a lead with the most nearly equiphasic or flat T wave. The T wave most nearly equiphasic in this tracing is located in lead V_3R. The mean horizontal T vector, therefore, may be fixed left and anterior at approximately +45° (Figure 128).

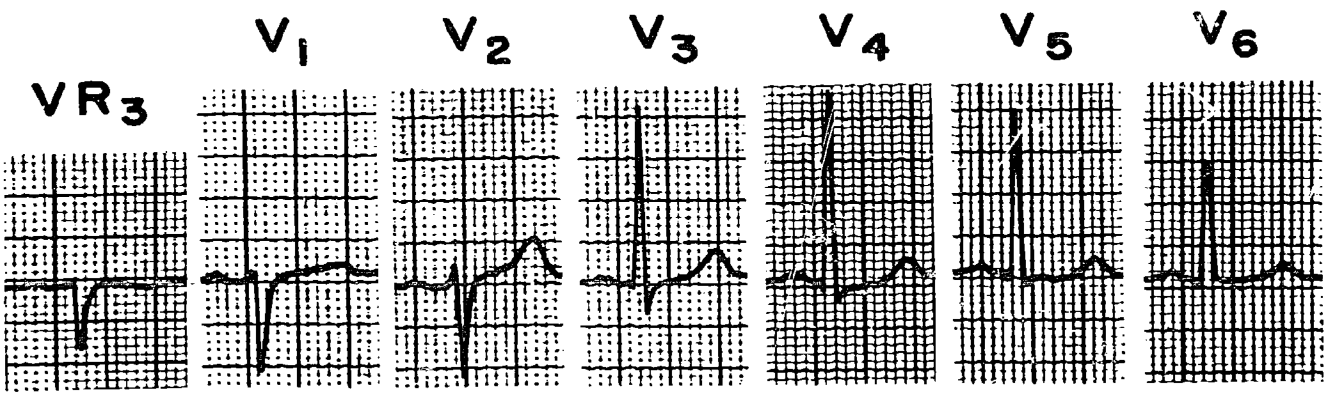


Figure 127

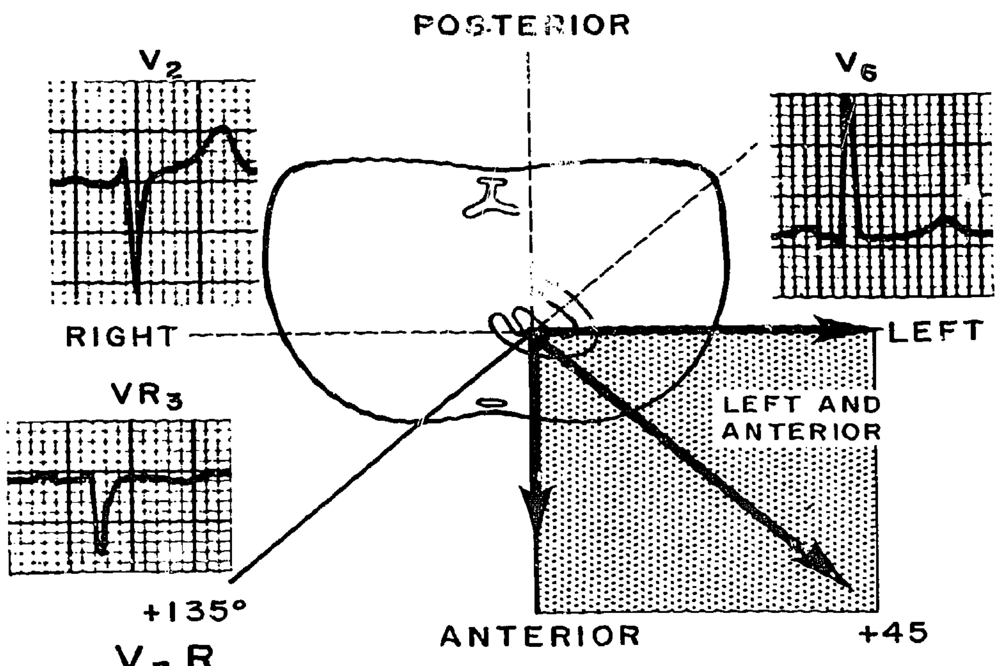


Figure 128

5. MEAN P VECTOR

5.1 *Mean Frontal P Vector* (Example 10)

Mean P vectors may be determined in a manner similar to the mean QRS and mean T vectors. In the frontal plane leads from an electrocardiogram (Figure 129), the upright P deflection in lead I indicates net atrial forces are *left;* the upright P deflection in lead AVF indicates net atrial forces are *inferior.*

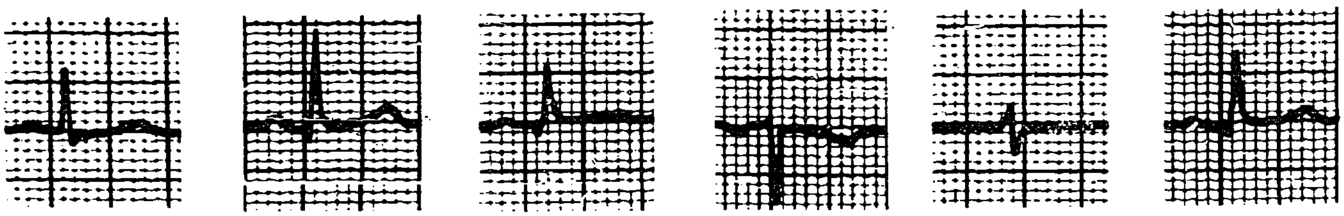


Figure 129

The Quadrant Rule, therefore, places the mean frontal P vector in the *left and inferior quadrant* (Figure 130).

Locating the mean P vector precisely in degrees often is difficult because atrial voltages are small. With small P wave voltages, it is difficult to locate the lead with the equiphasic or flat P wave. This tracing displays an equiphasic or flat P wave in lead AVL. The mean frontal P vector, therefore, lies perpendicular to the axis of lead AVL, in the preselected *left and inferior quadrant, at +60°* (Figure 130).

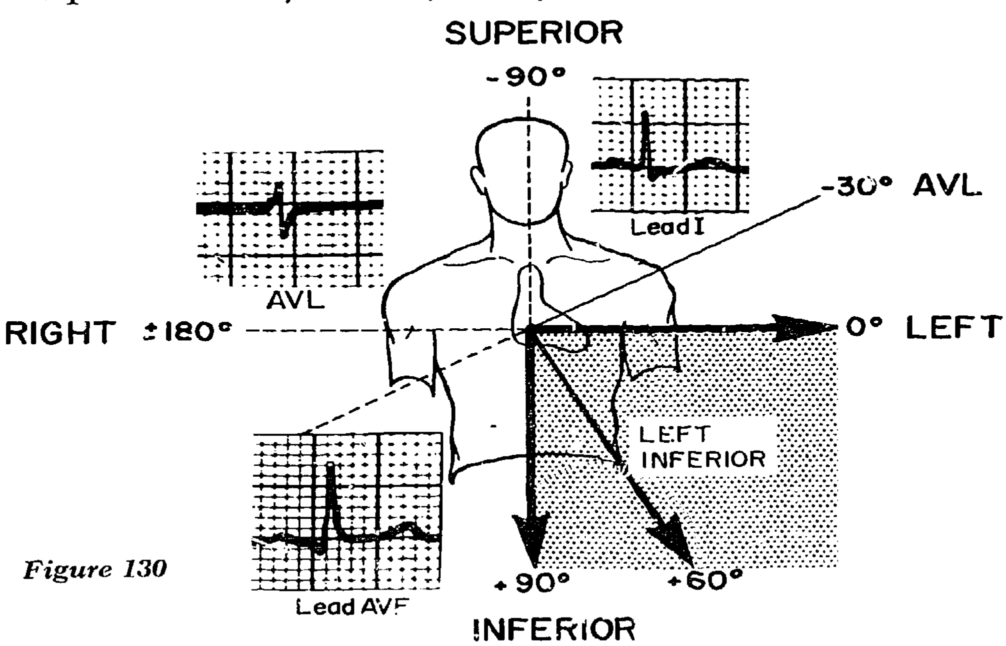


Figure 130

5.2 *Mean Horizontal P Vector*—(Example 11)

In the horizontal plane leads from an electrocardiogram (Figure 131), the predominant upright P wave deflections in leads V_2 and V_6 locate the mean horizontal P vector left and anterior (Figure 132). The equiphasic P deflection in lead V_1 fixes the mean horizontal P vector *left and anterior, at +30°.*

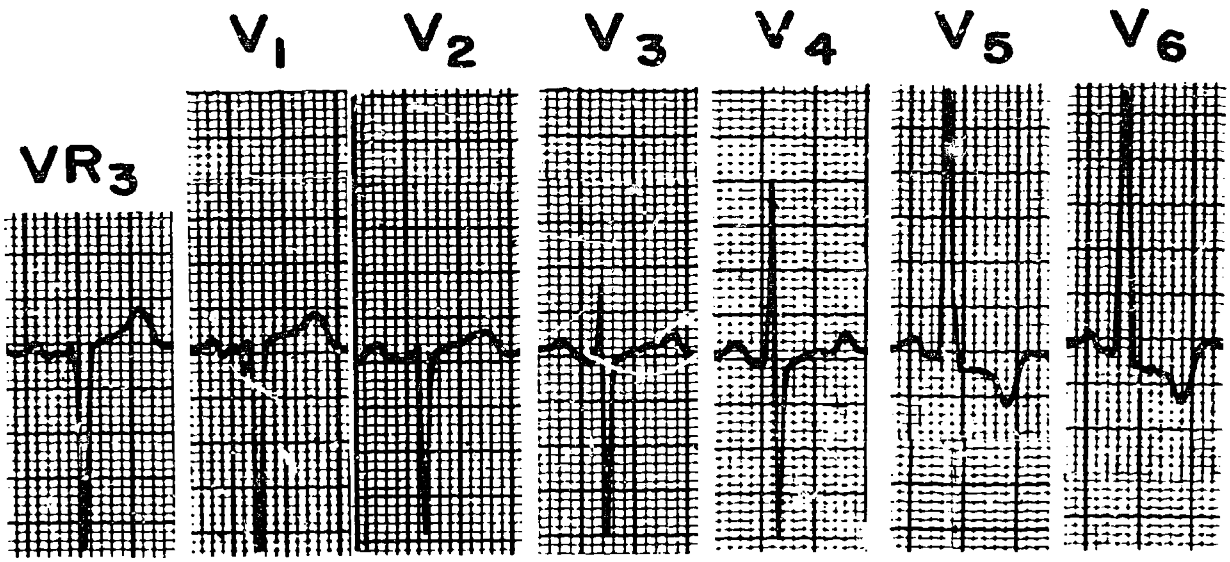


Figure 131

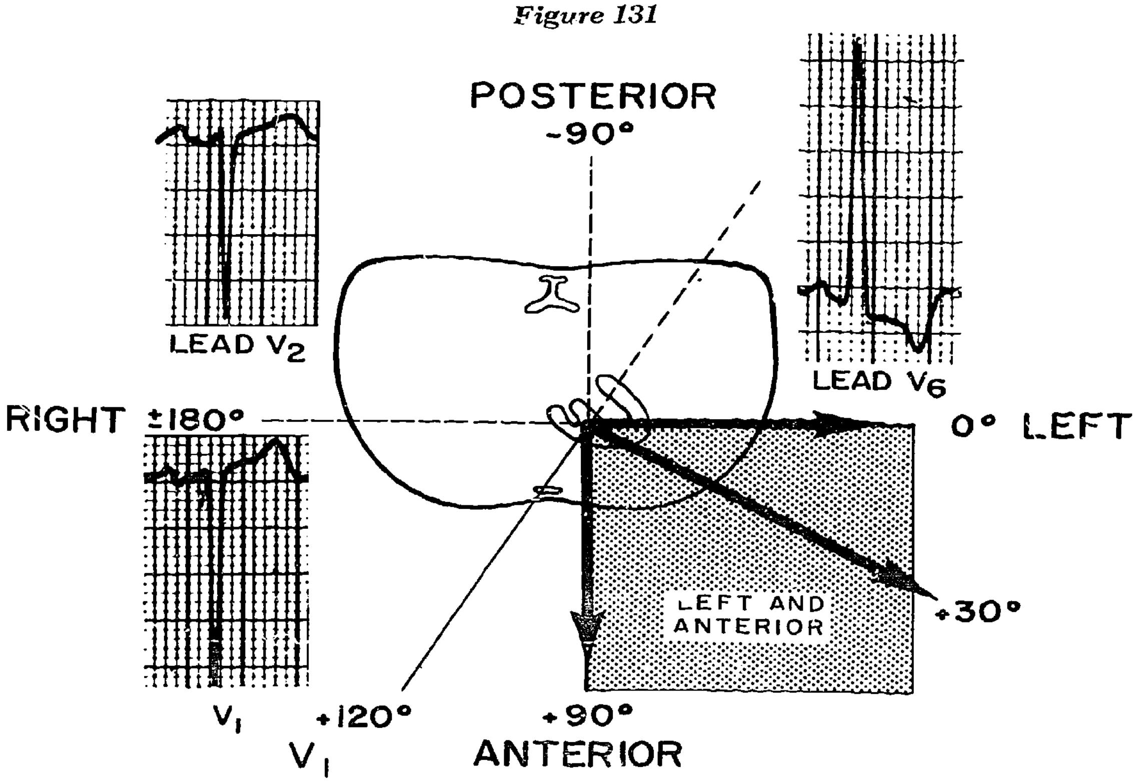


Figure 132

6. SUMMARY

This chapter, The Introduction to the Method of Spatial Analysis, has emphasized the following principles:

1. An upright deflection in any lead represents forces moving toward the positive electrode of that lead.

2. The three spatial axes of the body may be represented best by:

   a. Leads I or V_6 for the left-right axis,

   b. Lead AVF for the superior-inferior axis, and

   c. Leads V_1 or V_2 for the anterior-posterior axis.

An upright deflection, therefore, represents leftward forces in leads I or V_6, inferior forces in lead AVF, and anterior forces in leads V_1 or V_2.

3. Mean vectors may be localized by the *Quadrant and Perpendicular Rules of Spatial Analysis*. The mean frontal vector may be localized to a quadrant by combining the net directions of forces in the left-right and superior-inferior leads; the mean horizontal vector may be localized similarly utilizing the left-right and anterior-posterior leads.

4. The mean vector may be fixed more precisely in degrees by the *Perpendicular Rule of Spatial Analysis*. This rule states the mean vector lies perpendicular to the axis of the lead with the equiphasic complex and in the preselected quadrant.

5. You now should be able to determine the mean P, QRS, and T vectors of any electrocardiogram with this Method of Spatial Analysis.

END

APPENDIX - C

TEST BOOKLET

INTRODUCTION TO

THE SPATIAL ANALYSIS OF THE ELECTROCARDIOGRAM

This test will help us evaluate different methods of teaching. It is not designed to test you as an individual.

We appreciate your cooperation and hope we may repay you, in the future, with improved postgraduate programs.

DIRECTIONS

SCRATCH PAPER IS PROVIDED FOR CALCULATIONS.

PLEASE DO NOT WRITE ON THE TEST BOOKLET.

Do not open the test booklet until instructions and explanations have been given.

You have 30 minutes to complete this test. You will be told when to start.

Examine the ECG for each question. On the answer sheet place an "X" on the letter corresponding to the appropriate answer. Example:

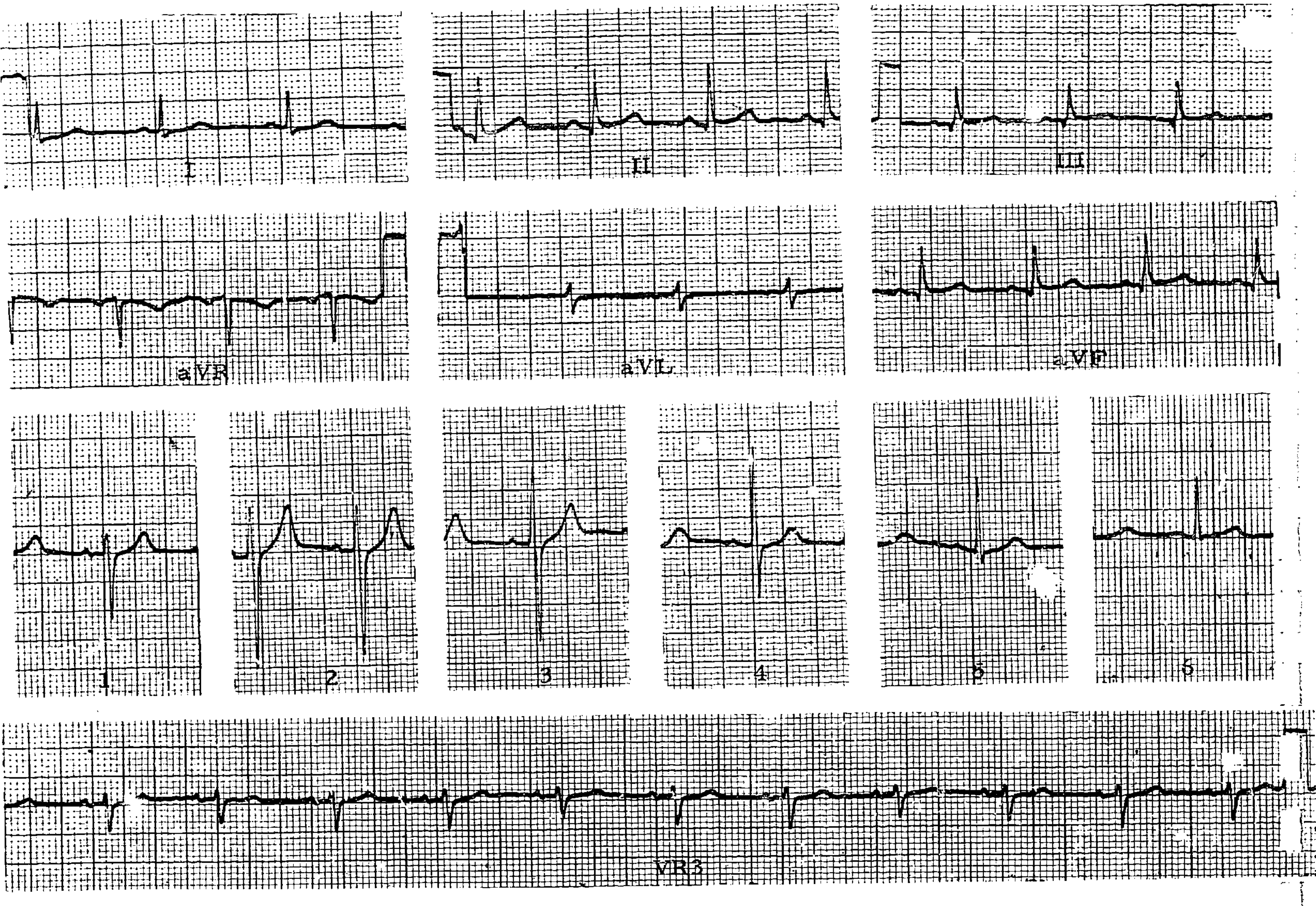
Problem Number	Answers
0	a b X d e

If you wish to change an answer, either erase the "X" completely or black out the letter, thus leaving no doubt as to the intended answer.

Problem Number	Answers
0	a b ● d X

When you have finished the test please hand the test material to the secretary.

* * *



ECG I

Questions 1 through 6

REFER TO ECG I

1. Localize the mean frontal QRS vector in one of the following quadrants:

FRONTAL QRS

a. Right and inferior
b. Left and inferior
c. Left and anterior
d. Left and superior
e. Right and superior

2. From the following choices localize the mean frontal QRS vector in degrees:

FRONTAL QRS

a. -30°
b. $+60^{\circ}$
c. 0°
d. $+30^{\circ}$
e. -120°

3. Localize the mean horizontal QRS vector in one of the following quadrants:

HORIZONTAL QRS

a. Right and anterior
b. Left and inferior
c. Left and anterior
d. Right and posterior
e. Left and posterior

4. From the following choices localize the mean horizontal QRS vector in degrees:

HORIZONTAL QRS

a. $+165^{\circ}$
b. $+30^{\circ}$
c. -15°
d. 0°
e. -60°

5. Localize the mean frontal T vector in one of the following quadrants:

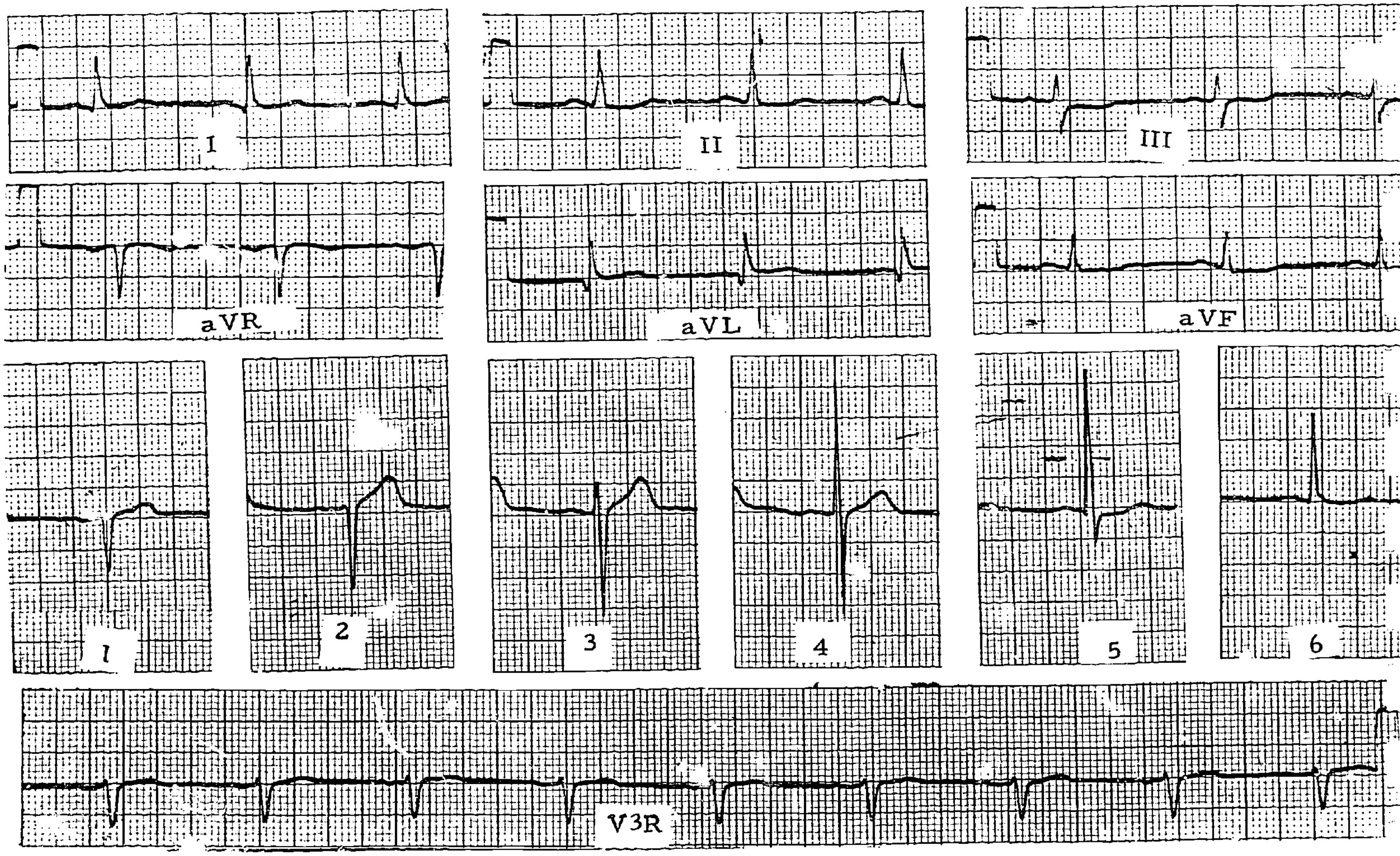
FRONTAL T

a. Left and superior
b. Right and superior
c. Left and anterior
d. Left and inferior
e. Right and inferior

6. From the following choices localize the mean frontal T vector in degrees:

FRONTAL T

a. $+60^{\circ}$
b. $+30^{\circ}$
c. 0°
d. -120°
e. -30°



ECG II

Questions 7 through 10

REFER TO ECG II

7. Localize the mean frontal QRS vector in one of the following quadrants:

a. Right and inferior
b. Right and superior
c. Left and inferior
d. Left and superior
e. Left and anterior

FRONTAL QRS

8. From the following choices localize the mean frontal QRS vector in degrees:

a. -120°
b. -150°
c. $+60^{\circ}$
d. -30°
e. $+30^{\circ}$

FRONTAL QRS

9. Localize the mean horizontal QRS vector in one of the following quadrants:

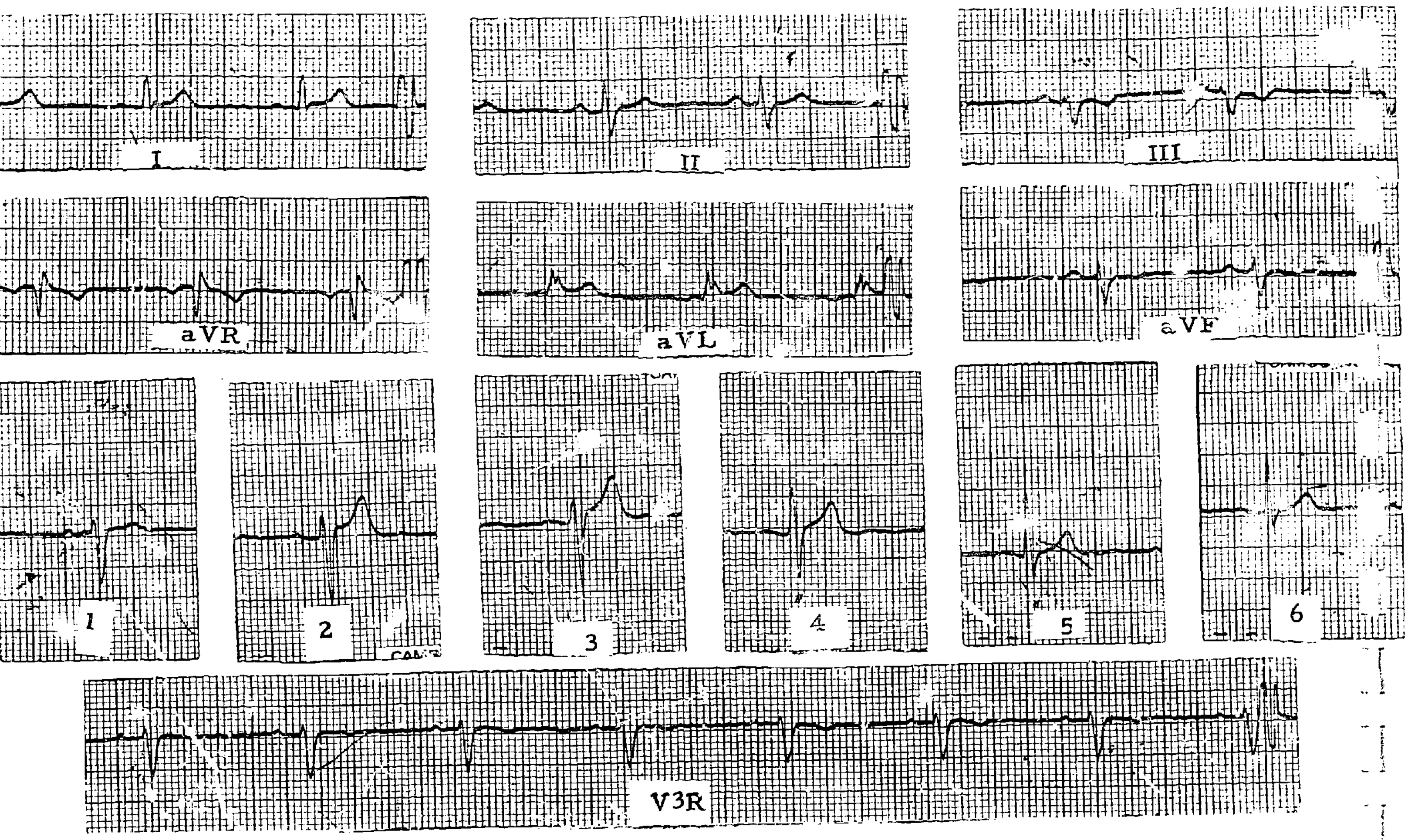
a. Left and posterior
b. Right and anterior
c. Right and posterior
d. Left and anterior
e. Left and inferior

HORIZONTAL QRS

10. From the following choices localize the mean horizontal QRS vector in degrees:

a. $+60^{\circ}$
b. $+150^{\circ}$
c. -30°
d. -120°
e. -60°

HORIZONTAL QRS



ECG III

Questions 11 through 16

REFER TO ECG III

11. Localize the mean frontal QRS vector in one of the following quadrants:

a. Left and inferior
b. Left and posterior
c. Right and inferior
d. Left and superior
e. Right and superior

FRONTAL QRS

12. From the following choices localize the mean frontal QRS vector in degrees:

a. -120°
b. 0°
c. -30°
d. $+60^{\circ}$
e. $+150^{\circ}$

FRONTAL QRS

13. Localize the mean horizontal QRS vector in one of the following quadrants:

a. Right and posterior
b. Left and anterior
c. Left and superior
d. Left and posterior
e. Right and anterior

HORIZONTAL QRS

14. From the following choices localize the mean horizontal QRS vector in degrees:

a. -150°
b. $+30^{\circ}$
c. -30°
d. -120°
e. $+120^{\circ}$

HORIZONTAL QRS

15. Localize the mean frontal T vector in one of the following quadrants:

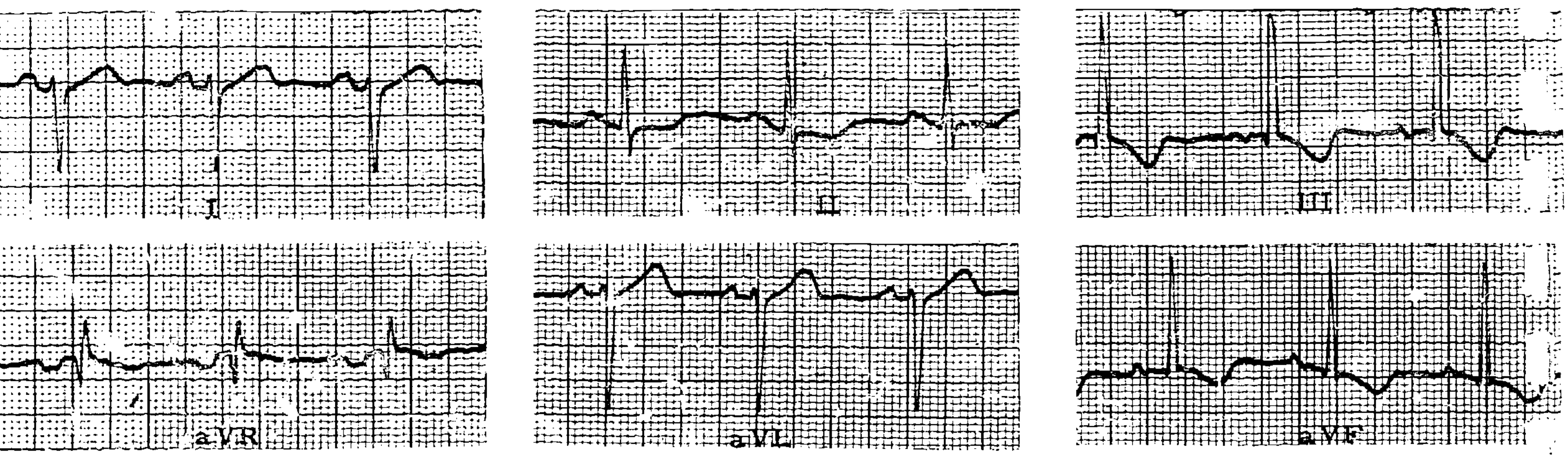
a. Left and neither superior nor inferior
b. Left and inferior
c. Right and superior
d. Left and superior
e. Right and inferior

FRONTAL T

16. From the following choices determine the mean frontal T vector in degrees:

a. 0°
b. $+90^{\circ}$
c. -90°
d. $+60^{\circ}$
e. -180°

FRONTAL T



ECG IV

Questions 17 through 22

REFER TO ECG IV

17. Localize the mean <u>frontal QRS</u> vector in one of the following quadrants:

a. Left and superior
b. Right and superior
c. Right and inferior
d. Left and anterior
e. Left and inferior

FRONTAL QRS

18. From the following choices determine the mean frontal QRS vector in degrees:

a. $- 60^{o}$
b. $- 150^{o}$
c. $+ 120^{o}$
d. $+ 60^{o}$
e. $+ 30^{o}$

FRONTAL QRS

19. Localize the mean frontal T vector in one of the following quadrants:

a. Left and superior
b. Right and superior
c. Left and inferior
d. Right and anterior
e. Right and inferior

FRONTAL T

20. From the following choices determine the mean frontal T vector in degrees:

a. $+ 120^{o}$
b. $- 150^{o}$
c. 0^{o}
d. $- 60^{o}$
e. $+ 60^{o}$

FRONTAL T

21. Localize the mean frontal P vector in one of the following quadrants:

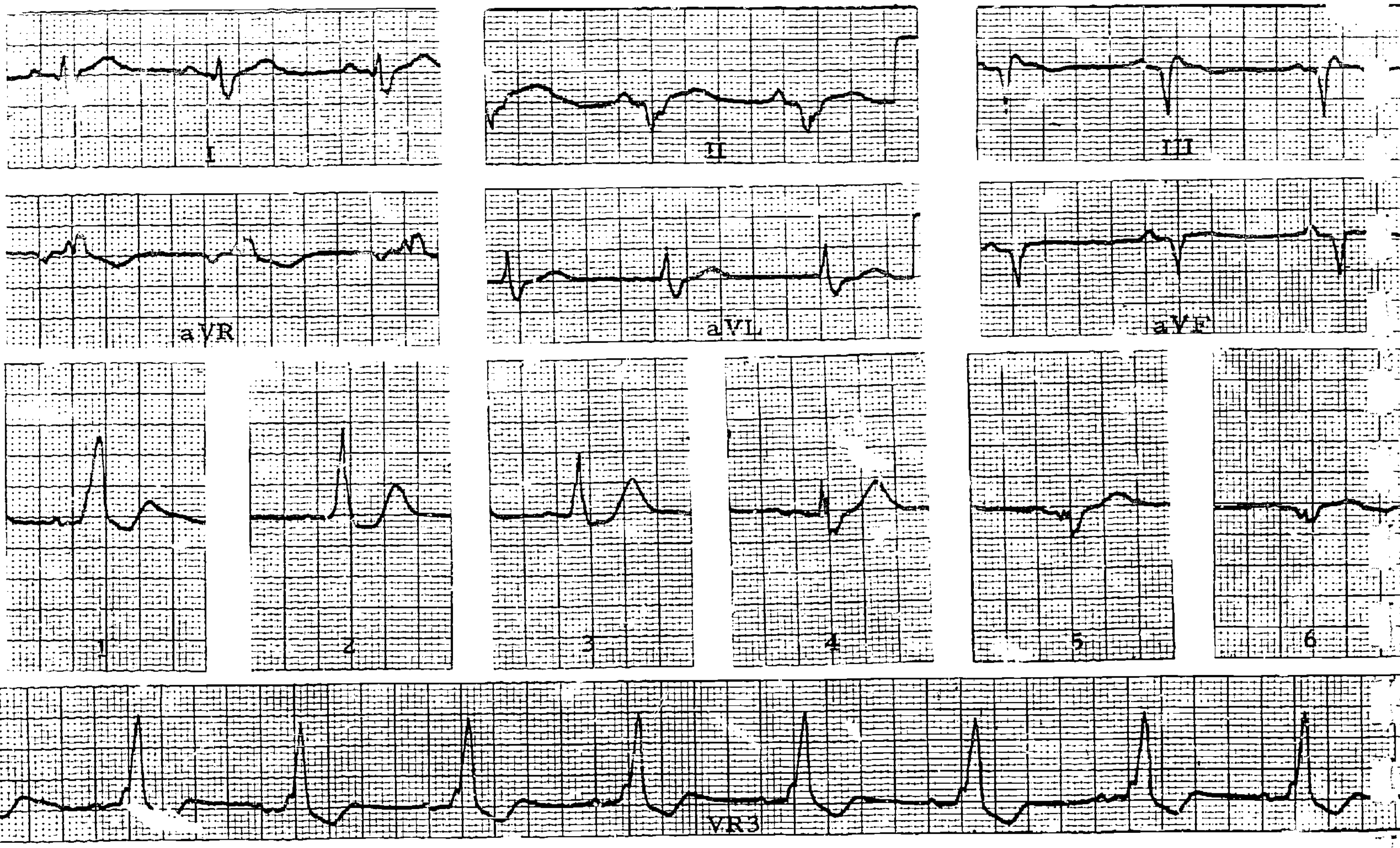
a. Left and superior
b. Left and anterior
c. Right and inferior
d. Left and inferior
e. Right and superior

FRONTAL P

22. From the following choices determine the mean frontal P vector in degrees:

a. $+ 120^{o}$
b. $+ 60^{o}$
c. $+ 30^{o}$
d. $- 30^{o}$
e. $- 60^{o}$

FRONTAL P



ECG V

Questions 23 through 26

REFER TO ECG V

23. Localize the mean frontal QRS vector in one of the following quadrants:

a. Right and inferior
b. Left and inferior
c. Right and superior
d. Left and posterior
e. Left and superior

FRONTAL QRS

24. From the following choices localize the mean frontal QRS vector in degrees:

a. $+60^{\circ}$
b. -30°
c. -60°
d. $+150^{\circ}$
e. -120°

FRONTAL QRS

25. Localize the mean horizontal QRS vector in one of the following quadrants:

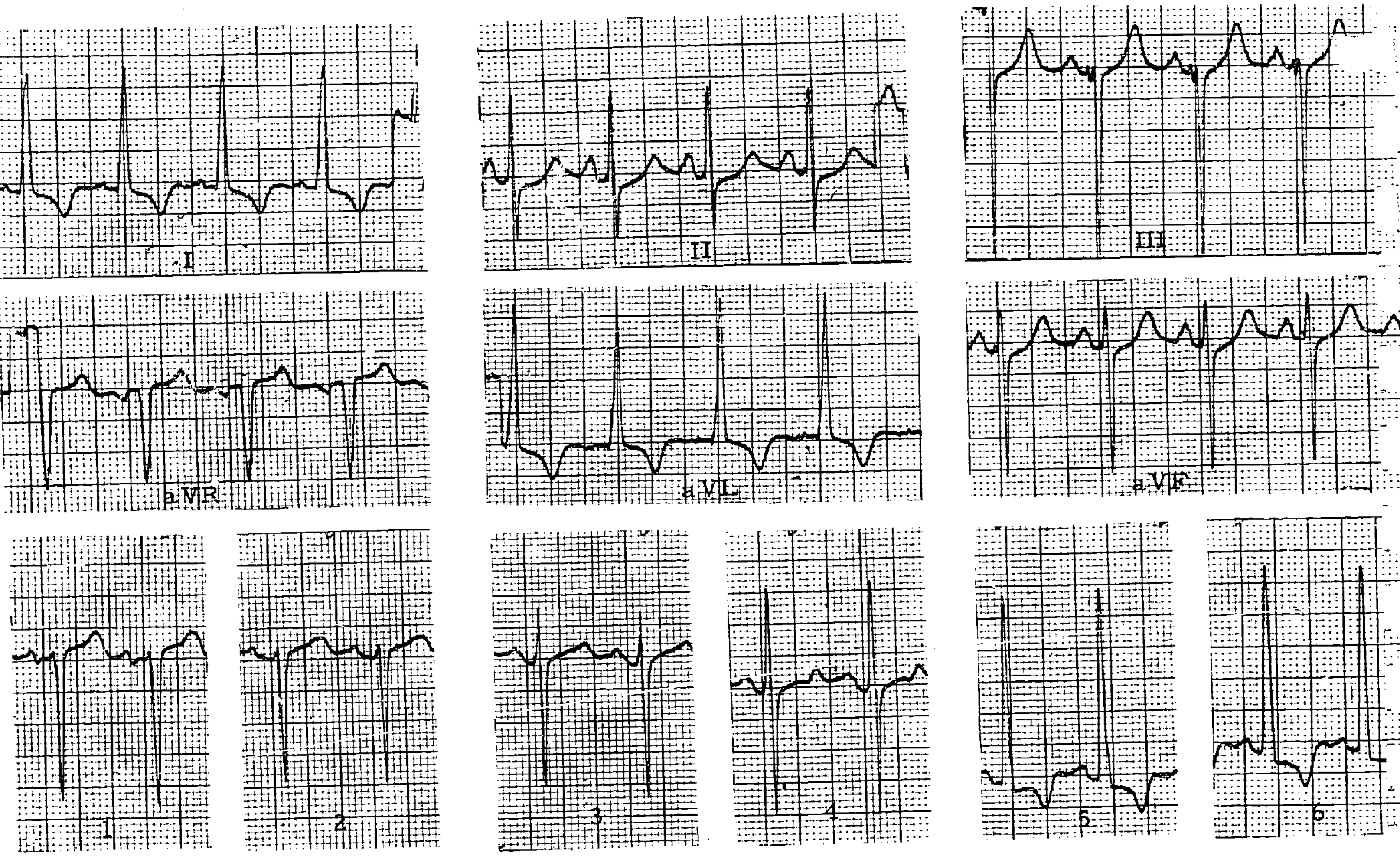
a. Right and inferior
b. Right and anterior
c. Right and posterior
d. Left and posterior
e. Left and anterior

HORIZONTAL QRS

26. From the following choices localize the mean horizontal QRS vector in degrees:

a. 0°
b. $+150^{\circ}$
c. -30°
d. $+60^{\circ}$
e. -120°

HORIZONTAL QRS



ECG VI

Questions 27 through 30

REFER TO ECG VI

27. Localize the mean frontal P vector in one of the following quadrants:

a. Left and inferior
b. Left and superior
c. Right and inferior
d. Right and superior
e. Right and posterior

FRONTAL
P

28. From the following choices localize the mean frontal P vector in degrees:

a. -120°
b. $+150^{\circ}$
c. $+30^{\circ}$
d. -30°
e. $+60^{\circ}$

FRONTAL
P

29. Localize the mean horizontal P vector in one of the following quadrants:

a. Right and anterior
b. Left and posterior
c. Left and inferior
d. Left and anterior
e. Right and posterior

HORIZONTAL
P

30. From the following choices localize the mean horizontal P vector in degrees:

a. 0°
b. $+30^{\circ}$
c. $+60^{\circ}$
d. $+120^{\circ}$
e. -30°

HORIZONTAL
P

APPENDIX - D

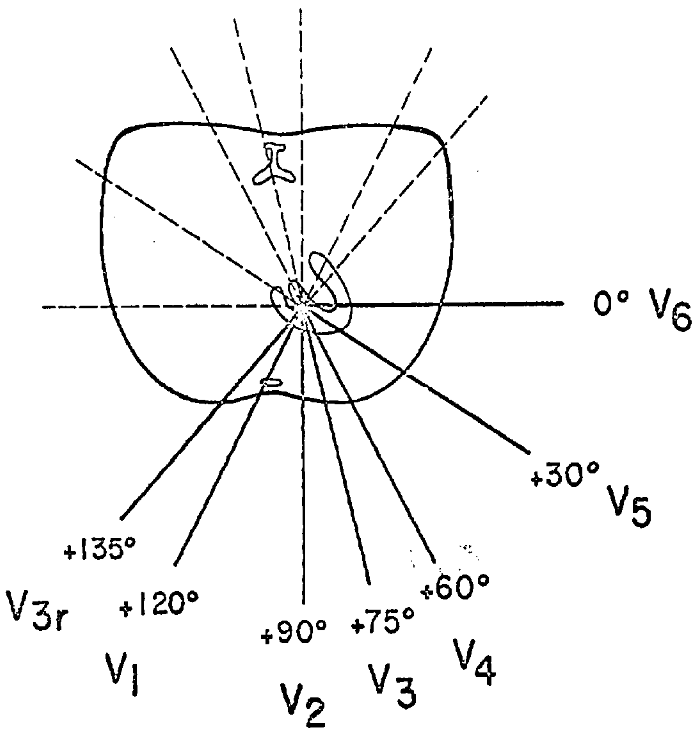
TEST BOOKLET

See Appendix C

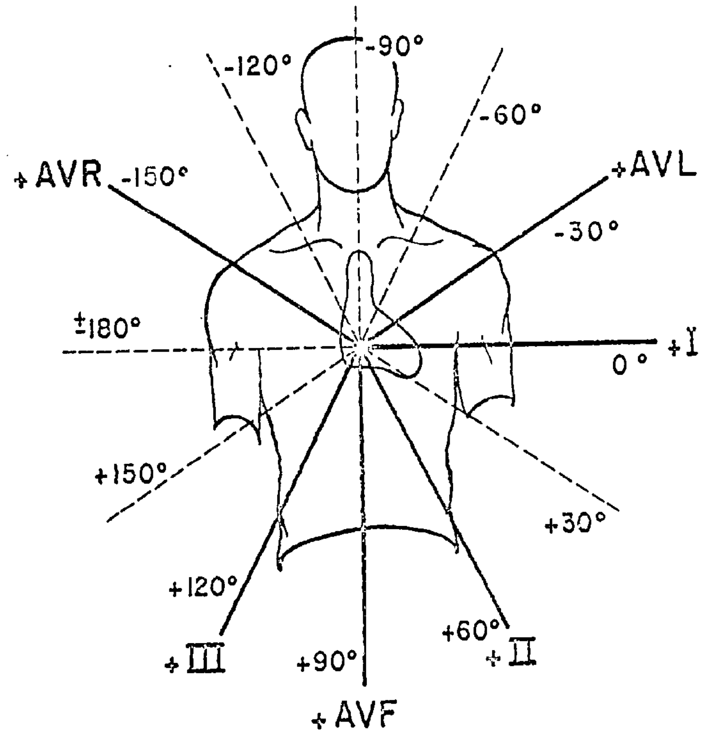
ANSWER SHEET

Identification Number ____________

Problem Number	Answer	Problem Number	Answer
1.	a b c d e	16.	a b c d e
2.	a b c d e	17.	a b c d e
3.	a b c d e	18.	a b c d e
4.	a b c d e	19.	a b c d e
5.	a b c d e	20.	a b c d e
6.	a b c d e	21.	a b c d e
7.	a b c d e	22.	a b c d e
8.	a b c d e	23.	a b c d e
9.	a b c d e	24.	a b c d e
10.	a b c d e	25.	a b c d e
11.	a b c d e	26.	a b c d e
12.	a b c d e	27.	a b c d e
13.	a b c d e	28.	a b c d e
14.	a b c d e	29.	a b c d e
15.	a b c d e	30.	a b c d e

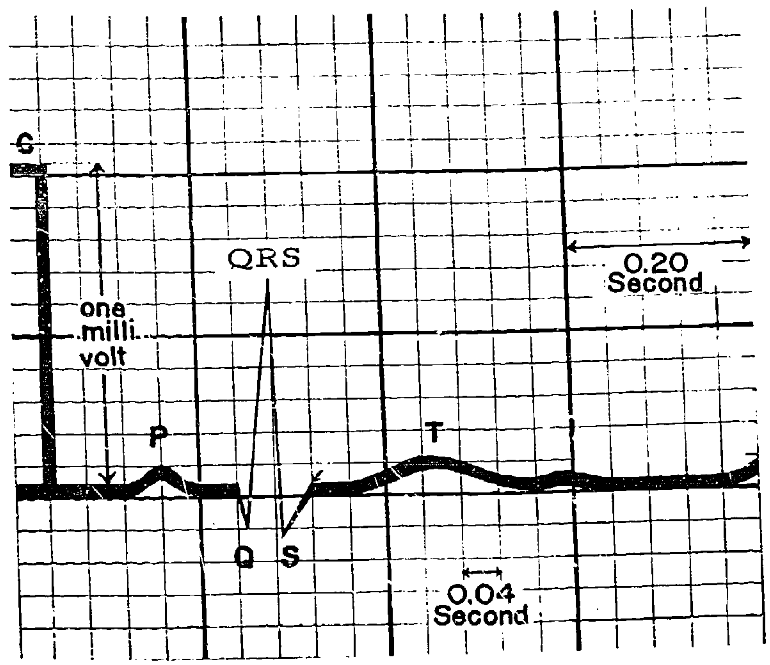


HORIZONTAL PLANE



FRONTAL PLANE

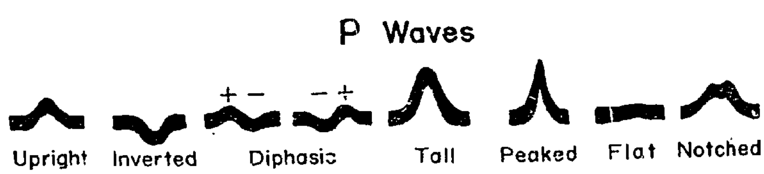
P, QRS, T

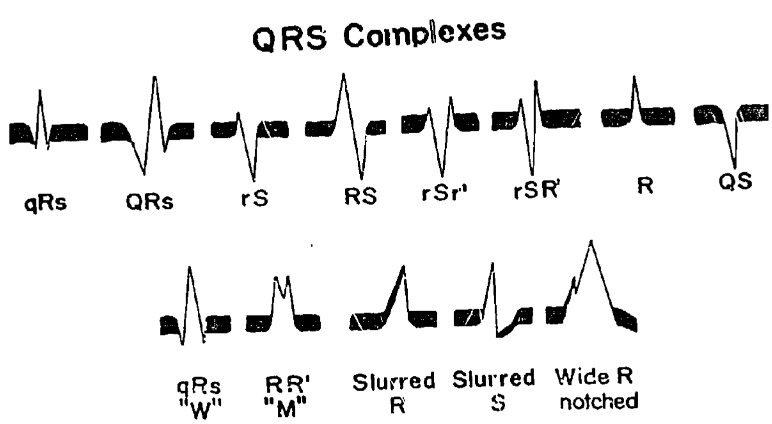


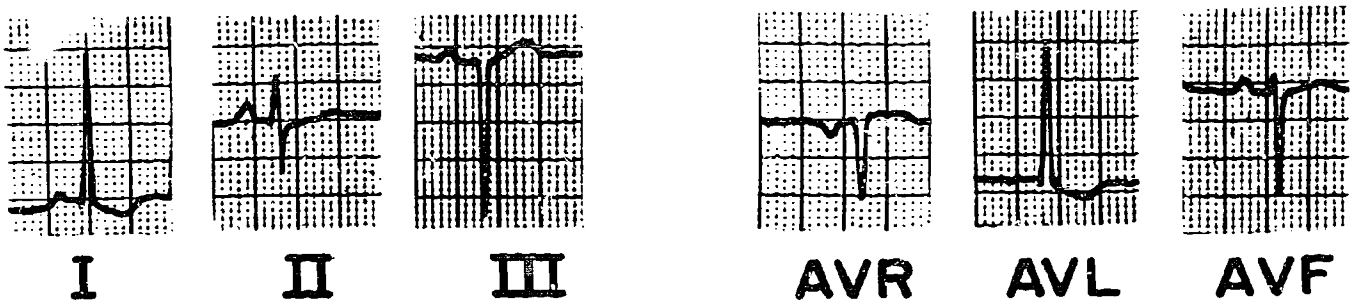
1. The P wave results from the activation wave spreading through the atria (depolarization of the atria).

2. The QRS complex results from the activation wave spreading through the ventricle from endocardium to epicardium (depolarization of the ventricle).

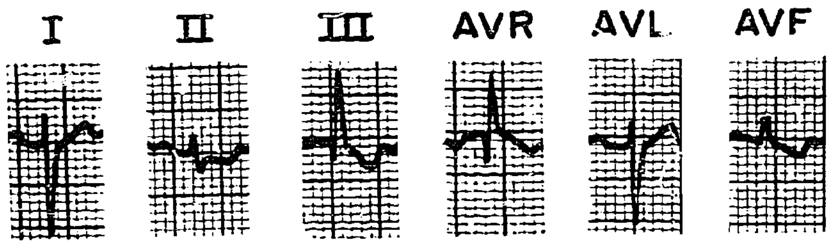
3. The T wave results from repolarization of the ventricles.



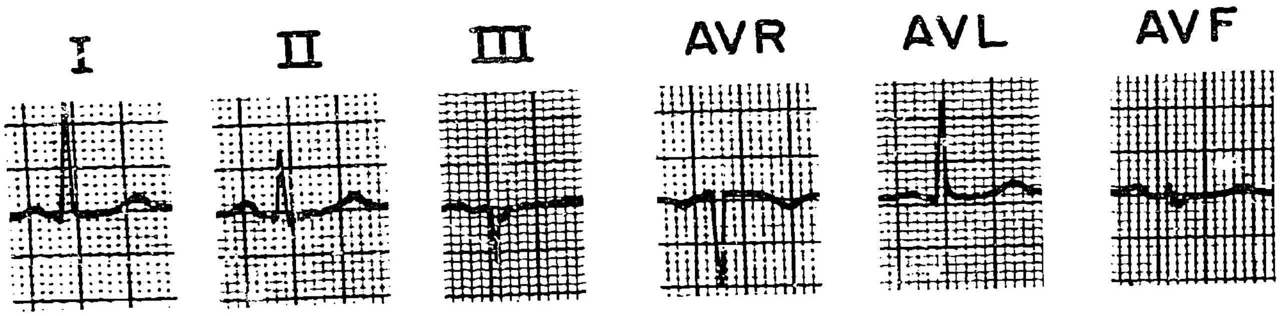




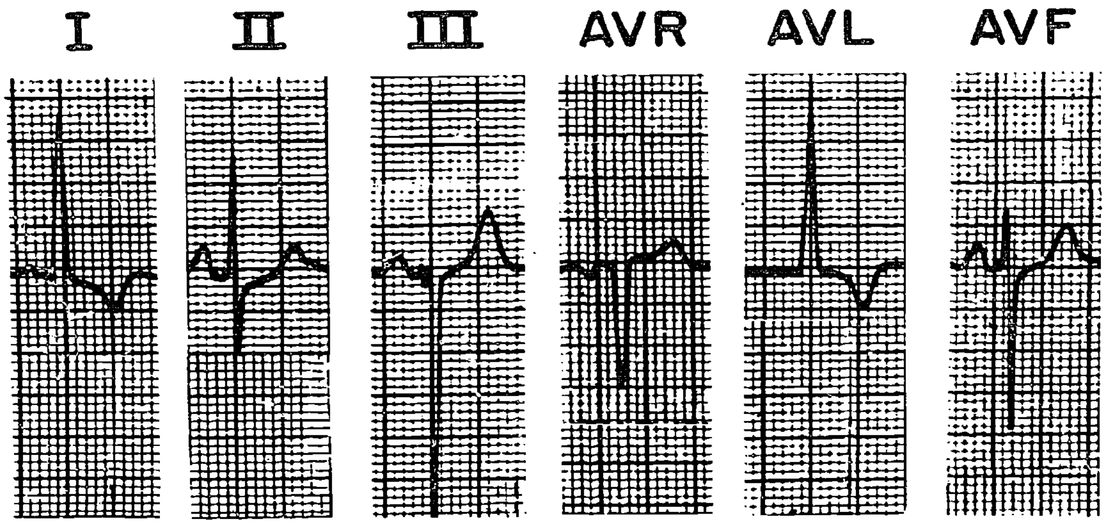
ECG I



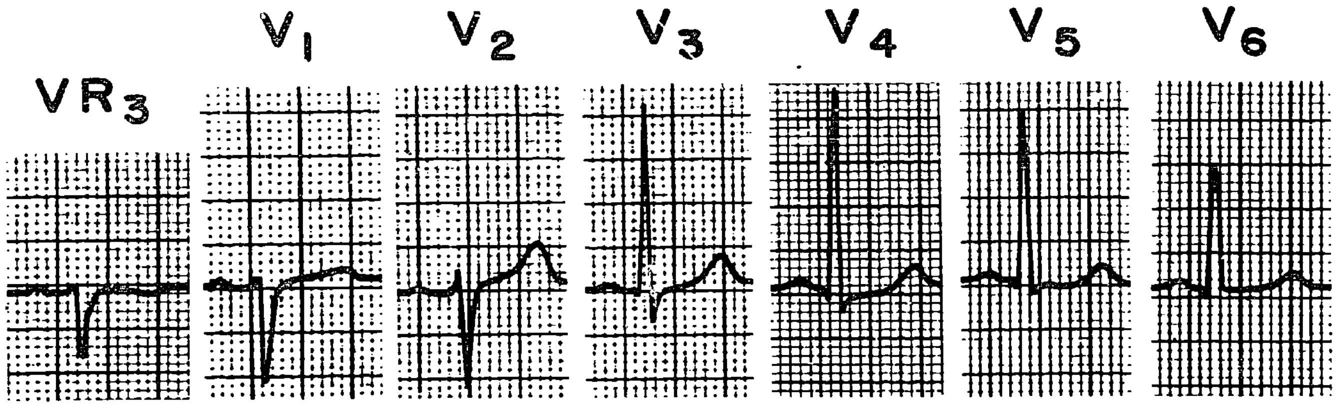
ECG II



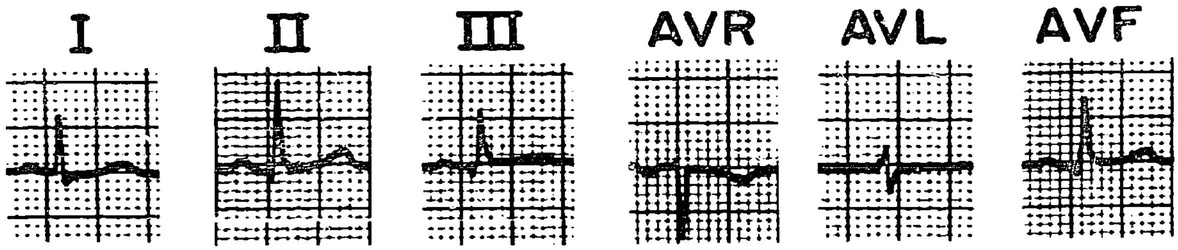
ECG III



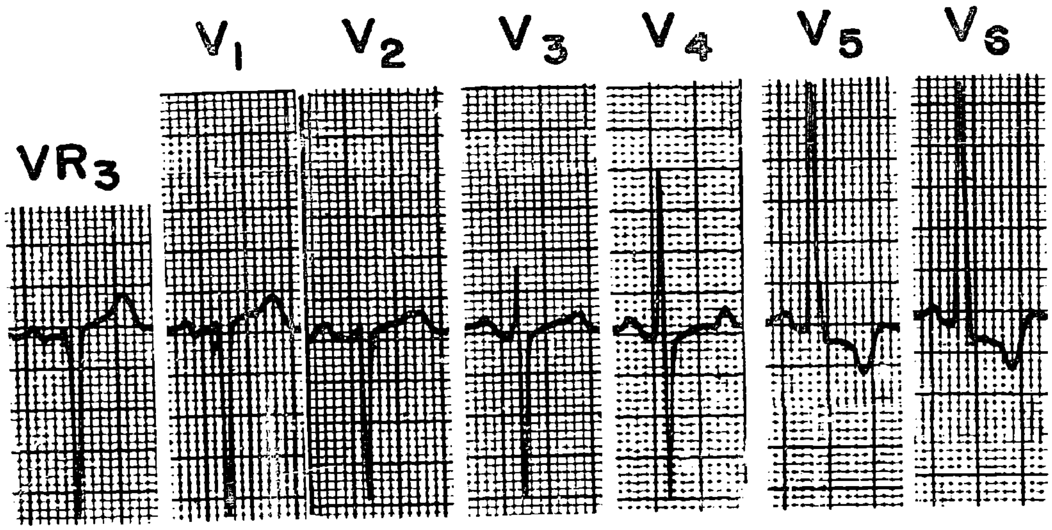
ECG IV



ECG V



ECG VI



ECG VII

ANSWER SHEET

Identification Number ______________

Problem Number	Answer	Problem Number	Answer
1.	a b c d e	16.	a b c d e
2.	a b c d e	17.	a b c d e
3.	a b c d e	18.	a b c d e
4.	a b c d e	19.	a b c d e
5.	a b c d e	20.	a b c d e
6.	a b c d e	21.	a b c d e
7.	a b c d e	22.	a b c d e
8.	a b c d e	23.	a b c d e
9.	a b c d e	24.	a b c d e
10.	a b c d e	25.	a b c d e
11.	a b c d e	26.	a b c d e
12.	a b c d e	27.	a b c d e
13.	a b c d e	28.	a b c d e
14.	a b c d e	29.	a b c d e
15.	a b c d e	30.	a b c d e

Total Study Time ______________

Total Test Time ______________

UNIVERSITY OF SOUTHERN CALIFORNIA
SCHOOL OF MEDICINE
OFFICE OF ASSOCIATE DEAN
FOR POSTGRADUATE AFFAIRS
2025 ZONAL AVENUE
LOS ANGELES, CALIFORNIA 90033

APPENDIX - E

UNIVERSITY OF SOUTHERN CALIFORNIA
SCHOOL OF MEDICINE
2025 ZONAL AVENUE
LOS ANGELES, CALIFORNIA 90033
CAPITOL 5-1511

OFFICE OF THE ASSOCIATE DEAN
FOR POSTGRADUATE AFFAIRS

April 14, 1967

I am deeply grateful to you for your participation in the experiment that tested various teaching techniques at Pebble Beach, March 2 and 3. We are currently scoring the pre and post test and will soon be evaluating the results.

In order to compare the experiment it is necessary for us to ask you to take one more short test. This can be completed in your office or home. Early in June you will be sent the test to complete. After that we will be able to give you a report on the most satisfactory teaching method.

Once again, thank you very much. You will be hearing from me in June.

Sincerely,

Phil R. Manning, M.D.
Associate Dean
Postgraduate Medical Education

PRM:mes

UNIVERSITY OF SOUTHERN CALIFORNIA
SCHOOL OF MEDICINE
2025 ZONAL AVENUE
LOS ANGELES, CALIFORNIA 90033
CApitol 5-1511

OFFICE OF THE ASSOCIATE DEAN
FOR POSTGRADUATE AFFAIRS

June 25, 1967

Further reference is made to the experiment on teaching techniques that you participated in at the Pebble Beach Meeting. You will recall that in order to complete the experiment I indicated it would be necessary to ask you to take one more test in your home or office. You will find enclosed a test book and answer sheet as well as the P, QRS, T sheet and the Frontal and Horizontal Plane illustrations.

It would be greatly appreciated if you would take the test, marking the answers on the test sheet, and send us the completed test sheet in the self-addressed stamped envelope. Upon the receipt of the completed tests we will send you the results obtained.

Please remember that we are interested in testing the instructional methods - not you. After we have received the test sheets the records of the performance of individual physicians will be destroyed.

Our faculty will be most appreciative to you for your participation in this important experiment.

Sincerely,

Phil R. Manning, M.D.
Associate Dean
Postgraduate Medical Education

PRM:mes

APPENDIX - F

UNIVERSITY OF SOUTHERN CALIFORNIA
SCHOOL OF MEDICINE
2025 ZONAL AVENUE
LOS ANGELES, CALIFORNIA 90033
CAPITOL 5-1511

OFFICE OF THE ASSOCIATE DEAN
FOR POSTGRADUATE AFFAIRS

July 25, 1967

Further reference is made to your participation in the experiment on medical education at the Pebble Beach meeting.

I am pleased to announce that we are receiving the final post-test from many of the physicians that participated. However, in order that our figures may have reliability, it is important that we receive the final post-test from every participant. I would very much appreciate your completing the enclosed test and sending it to us as soon as possible. In the event that you have lost the previous test, I am enclosing another one.

Sincerely,

Phil R. Manning, M.D.
Associate Dean
Postgraduate Medical Education

PRM:mes
Enclosure

UNIVERSITY OF SOUTHERN CALIFORNIA
SCHOOL OF MEDICINE
2025 ZONAL AVENUE
LOS ANGELES, CALIFORNIA 90033
CAPITOL 5-1511

OFFICE OF THE ASSOCIATE DEAN
FOR POSTGRADUATE AFFAIRS

Reference is made to your participation in the teaching experiment that was held in Pebble Beach, March 2 and 3, 1967.

Our statistics show that all of the teaching methods were successful and about equal in so far as learning gain is concerned. The two books, i.e. programmed text and the regular text accomplished about the same learning gain as the lecture workshop and the lecture demonstration but in a shorter time. Attached you will see the average scores and times for the four methods. You will also see your individual scores.

Once again, thank you very much for your participation in this teaching experiment. From the results we hope to improve our teaching methods and consequently offer better continuing education programs in the future.

Sincerely,

Phil R. Manning, M.D.
Associate Dean
Postgraduate Medical Education

PRM:ms
Encl - 1

PEBBLE BEACH ECG EXPERIMENT IN THE SPATIAL ANALYSIS OF THE ELECTROCARDIOGRAM

	Average Scores			Mean Time
	Pretest	Post test	Delayed Post test	
Programmed Text	6	22	14	73 minutes
Narrative Text	9	24	15	49 minutes
Lecture Workshop	3	21	13	49 minutes
Lecture Demonstration	7	22	16	90 minutes

Your Score

Pretest -

Post test -

Delayed Post test -

APPENDIX - G

RAW DATA

PEBBLE BEACH, CALIFORNIA

PROGRAMMED TEXT

Identification Number	Pretest Score	Posttest Score	Time	Delayed Posttest Score
1002	21	28	15	
1006	04	26		
1013	00	05		00
1026	00	28	28	
1035	02	30	25	21
1036	0[illegible]	22		21
10[illegible]6	0[illegible]	27		16
1058	18	27	12	
1059	19	30		30
1076	00	12	20	00
1092	00	20	30	00
1096	00	18	30	00
1098	00	27		
1101	00	16	20	
1103	12	26	25	17
1104	03	23	29	
1108	00	27		20
1112	00	29		00
1119	03	08		
1124	02	29		01
1127	06	07		08
1152	00	27		
1153	24	28		27
1156	00	18		06
1197	00	20	30	
1215	24	28		
1216	06	29	17	28
1230	06	16		
1236	11	30	13	19
1247	13	19		23
1248	03	28		30
1251	08	29	10	24
1258	08	03		
1272	03	21.		13

PEBBLE BEACH, CALIFORNIA - continued

NARRATIVE TEXT

Identification Number	Pretest Score	Posttest Score	Time (min.)	Delayed Posttest Score
3020	03	28		
3033	05	29		
3038	10	30	15	0
3050	09	27		[illegible]8
3053	10	26	[illegible]	09
3062	00	28	25	30
3064	19	28	12	
3079	00	09		00
3081	13	29		
3085	04	29	15	26
3093	17	27	20	11
3097	00	20	[illegible]	07
3102	14	20		
3107	14	29	25	13
3111	26	28	15	28
3120	03	08	25	06
3123	29	30	16	30
3157	01	06		
3171	00	29	33	
3174	18	30	18	29
3176	11	30	18	23
3179	22	30		30
3180	04	25		00
3184	03	26	28	09
3186	21	28	26	16
3189	03	29	15	
3193	02	09		02
3194	04	28	23	
3196	08	19		13
3206	00	26		20
3213	06	24		02
3233	10	15	27	
3238	14	30	30	
3265	01	18.	30	
3274	11	28	30	

PEBBLE BEACH, CALIFORNIA - continued

LECTURE - WORKSHOP

Identification Number	Pretest Score	Posttest Score	Delayed Posttest Score
2010	00	30	
2015	01	26	0[illegible]
2042	08	20	0[illegible]
2051	00	12	00
2054	00	25	06
2056	00	14	
2063	00	02	00
2065	00	28	
2069	00	22	18
2070	00	29	24
2071	12	26	07
2075	00	21	00
2080	00	26	
2095	00	24	
2105	00	27	30
2106	00	14	
2129	00	20	
2130	24	30	30
2134	00	29	30
2140	04	27	
2145	12	30	
2151	00	23	25
2154	00	17	00
2160	00	11	
2161	08	12	
2162	00	11	
2165	01	30	
2181	16	30	15
2182	00	29	
2190	22	30	29
2191	00	27	
2217	00	30	19
2223	00	14	01
2227	05	27	
2235	00	26	29
2241	00	23	
2250	00	15	
2253	23	26	22

PEBBLE BEACH, CALIFORNIA - continued

LECTURE - WORKSHOP cont.

Identification Score	Pretest Score	Posttest Score	Delayed Posttest Score
2262	01	10	
2271	00	22	

LECTURE - DEMONSTRATION

4003	00	08	
4012	00	29	17
4019	00	23	00
4021	05	27	00
4023	00	30	30
4029	03	24	
4030	00	27	00
4031	04	18	01
4041	00	13	
4043	03	26	07
4052	08	26	23
4060	00	16	
4077	18	29	
4091	26	30	26
4109	06	26	
4141	16	29	27
4147	08	14	
4155	03	30	29
4159	00	30	01
4173	23	27	23
4198	00	08	
4203	03	12	
4204	07	09	
4210	00	27	
4211	10	30	26
4222	.28	29	
4231	22	30	28
4232	00	24	28
4237	00	08	
4244	00	02	00
4245	04	29	22

PEBBLE BEACH, CALIFORNIA - continued

LECTURE - DEMONSTRATION, cont.

Identification Number	Pretest Score	Posttest Score	Delayed Posttest Score
4257	30	30	23
4260	07	20	20
4263	13	18	06
4266	12	29	
4267	00	20	

APPENDIX - H

UNIVERSITY OF SOUTHERN CALIFORNIA
SCHOOL OF MEDICINE
2025 ZONAL AVENUE
LOS ANGELES, CALIFORNIA 90033
CAPITOL 5-1511

OFFICE OF THE ASSOCIATE DEAN
FOR POSTGRADUATE AFFAIRS

Inasmuch as you previously have subscribed to one of our correspondence courses in Electrocardiography, I thought you would be interested in learning about a correspondence program which teaches the plotting of mean cardiac vectors from the standard electrocardiogram. Since the Home Course in Electrocardiography was published, there has been much interest in ECG's vectors.

We have developed a well-illustrated booklet on the subject that we feel would allow you to understand and plot mean cardiac vectors in the horizontal and frontal planes from standard ECG'S. Currently, the booklet is not for sale, as we have decided to study its value as a teaching method. If you would like to participate, I will be pleased to send you a booklet free of charge. The booklet, incidentally, may be kept by you after you complete the study which will take about two hours. The advantages to you would be the opportunity to learn how to plot mean cardiac vectors through this postgraduate correspondence course, for which there would be no charge.

Your participation would aid the Postgraduate Division in determining various advantages of the teaching method. If you are interested in participating in this experiment, please indicate your intention on the enclosed card.

Sincerely yours,

Phil R. Manning, M.D.
Associate Dean
Postgraduate Medical Education

PRM:mes
Enclosure

PHIL R. MANNING, M. D.:

_____ I wish to participate in the postgraduate experimental course in plotting cardiac vectors.

_____ I do not wish to participate in the postgraduate experimental course in plotting cardiac vectors.

X ______________________
Signature

Date. ______________ ______________________

Zip Code ______________

THIS SIDE OF CARD IS FOR ADDRESS

University of Southern California
School of Medicine
Postgraduate Division
2025 Zonal Avenue
Los Angeles 33, California 90033

APPENDIX - I

UNIVERSITY OF SOUTHERN CALIFORNIA
SCHOOL OF MEDICINE
2025 ZONAL AVENUE
LOS ANGELES, CALIFORNIA 90033
CAPITOL 5-1511

OFFICE OF THE ASSOCIATE DEAN
FOR POSTGRADUATE AFFAIRS

April 24, 1967

I am pleased to learn that you desire to participate in the experiment on the teaching methods for the plotting of mean cardiac vectors. I think that through your participation you will gain a good understanding of the spatial vector approach to ECG interpretation.

In order that the method may be tested, we would appreciate your completing the enclosed test and returning it to us immediately. When we receive the completed pre-test, we will send you the booklet which will teach you how to plot mean cardiac vectors in the frontal and horizontal plane. At that time, you will be asked to complete a post-test. In this way we will be able to evaluate the learning gain. Remember, we will be testing the method and not you. No records of individual accomplishment will be kept.

In the event that you had no previous experience with vectors and find the pre-test difficult, please do not be discouraged. Do what you can with the test and return it to us. Our experiment indicates that individuals that have had no experience with vectors gain a good understanding following their study of the booklet.

Sincerely yours,

Phil R. Manning, M.D.
Associate Dean
Postgraduate Medical Education

PRM:mes

APPENDIX - J

UNIVERSITY OF SOUTHERN CALIFORNIA
SCHOOL OF MEDICINE
2025 ZONAL AVENUE
LOS ANGELES, CALIFORNIA 90033
CAPITOL 5-1511

OFFICE OF THE ASSOCIATE DEAN
FOR POSTGRADUATE AFFAIRS

April 24, 1967

I am pleased to learn that you desire to participate in the experiment on the teaching methods for the plotting of mean cardiac vectors. I think that through your participation you will gain a good understanding of the spatial vector approach to ECG interpretation.

In order that the method may be tested, we would appreciate your completing the enclosed test and returning it to us immediately. When we receive the completed pre-test, we will send you the booklet which will teach you how to plot mean cardiac vectors in the frontal and horizontal plane. At that time, you will be asked to complete a post-test. In this way we will be able to evaluate the learning gain. Remember, we will be testing the method and not you. No records of individual accomplishment will be kept.

In the event that you had no previous experience with vectors and find the pre-test difficult, please do not be discouraged.Do what you can with the test and return it to us. Our experiment indicates that individuals that have had no experience with vectors gain a good understanding following their study of the booklet.

Sincerely yours,

Phil R. Manning, M.D.
Associate Dean
Postgraduate Medical Education

PRM:mes

APPENDIX - K

UNIVERSITY OF SOUTHERN CALIFORNIA
SCHOOL OF MEDICINE
2025 ZONAL AVENUE
LOS ANGELES, CALIFORNIA 90033
CAPITOL 5-1511

OFFICE OF THE ASSOCIATE DEAN
FOR POSTGRADUATE AFFAIRS

Enclosed is the booklet that will teach you how to plot mean cardiac vectors in the frontal and horizontal plane from the standard electrocardiogram. We appreciate your participation in this evaluation study.

After you have completed studying the booklet, please take the enclosed test. This should be done without the help of the booklet following the completion of your study. We also would appreciate a notation on the test sheet as to how long it took you to complete the study booklet.

Upon completion of the test, please mail the test answer sheet to us at once in the enclosed self-addressed stamped envelope. We will keep you informed as to our results. Thank you very much for your help. Once again, we are trying to test the method and not you personally.

Sincerely yours,

Phil R. Manning, M. D.
Associate Dean
Postgraduate Medical Education

ANSWER SHEET

Identification Number ____________

Problem Number	Answer	Problem Number	Answer
1.	a b c d e	16.	a b c d e
2.	a b c d e	17.	a b c d e
3.	a b c d e	18.	a b c d e
4.	a b c d e	19.	a b c d e
5.	a b c d e	20.	a b c d e
6.	a b c d e	21.	a b c d e
7.	a b c d e	22.	a b c d e
8.	a b c d e	23.	a b c d e
9.	a b c d e	24.	a b c d e
10.	a b c d e	25.	a b c d e
11.	a b c d e	26.	a b c d e
12.	a b c d e	27.	a b c d e
13.	a b c d e	28.	a b c d e
14.	a b c d e	29.	a b c d e
15.	a b c d e	30.	a b c d e

Total Study Time ____________

Total Test Time ____________

APPENDIX - L

UNIVERSITY OF SOUTHERN CALIFORNIA
SCHOOL OF MEDICINE
2025 ZONAL AVENUE
LOS ANGELES, CALIFORNIA 90033
CApitol 5-1511

OFFICE OF THE ASSOCIATE DEAN
FOR POSTGRADUATE AFFAIRS

July 11, 1967

Reference is made to your participation in the experiment on teaching techniques in Electrocardiography. We have received the pre-test that you took and have sent you the teaching booklet together with a post-test. It would be very helpful to us if you could complete the post-test and send it to us in the enclosed self-addressed stamped envelope. I have also enclosed another copy of the post-test in the event the other became misplaced.

Sincerely,

Phil R. Manning, M. D.
Associate Dean
Postgraduate Medical Education

PRM:mes
Encl - 2

UNIVERSITY OF SOUTHERN CALIFORNIA
SCHOOL OF MEDICINE
2025 ZONAL AVENUE
LOS ANGELES, CALIFORNIA 90033
CAPITOL 5-1511

OFFICE OF THE ASSOCIATE DEAN
FOR POSTGRADUATE AFFAIRS

March 1, 1968

Reference is made to your participation in the experiment on teaching techniques in Electrocardiography. We have received the pretest that you took and have sent you the teaching booklet together with a posttest. It would be very helpful to us if you could complete the posttest and send it to us in the enclosed self-addressed stamped envelope.

I realize that even the twenty to thirty minutes necessary to complete the test may be a hardship in your busy schedule. Never-the-less, completion of the posttest should be helpful in the learning situation and is very necessary to us if we are to judge the outcome of this teaching method. Please remember we are evaluating the teaching method and not you. All names and numbers of the participating physicians are destroyed upon completion of the final posttest.

I have also enclosed another copy of the posttest in the event the other became misplaced.

Sincerely,

Phil R. Manning, M.D.
Associate Dean
Postgraduate Medical Education

PRM:mes
Encl

UNIVERSITY OF SOUTHERN CALIFORNIA
SCHOOL OF MEDICINE
2025 ZONAL AVENUE
LOS ANGELES, CALIFORNIA 90033
CApitol 5-1511

OFFICE OF THE ASSOCIATE DEAN
FOR POSTGRADUATE AFFAIRS

April 19, 1968

Reference i: made to your participation in the experiment on teaching techniques in electrocardiography. We have received the pretest that you took and have sent you the teaching booklet together with a posttest. It would be most helpful to us if you could complete the posttest and send it to us in the enclosed self-addressed stamped envelope.

I realize that even the twenty to thirty minutes necessary to complete the test may be a hardship in your busy schedule. Never-the-less, completion of the posttest should be helpful in the learning situation and is very necessary to us if we are to judge the outcome of this teaching method. Please remember we are evaluating the teaching method and not you. All names and numbers of the participating physicians are destroyed upon completion of the final posttest.

I have also enclosed another copy of the posttest in the event the other became misplaced.

Sincerely,

Phil R. Manning, M.D.
Associate Dean
Postgraduate Medical Education

PRM:mes
Encl

P.S. - I do hope it is possible for you to finish the posttest - mailing it to me by May 6, 1968 - as the deadline for completion of our statistics is very near.
PRM

UNIVERSITY OF SOUTHERN CALIFORNIA
SCHOOL OF MEDICINE
2025 ZONAL AVENUE
LOS ANGELES, CALIFORNIA 90033
CApitol 5-1511

FFICE OF THE ASSOCIATE DEAN
FOR POSTGRADUATE AFFAIRS

Reference is made to your participation in the correspondence experiment of The Spatial Analysis of the Electrocardiogram.

Our statistics show that the two teaching methods were successful and about equal in so far as learning gain is concerned. Attached you will see the average scores for the programmed text and the narrative text. You will also see your individual scores.

Once again, thank you very much for your participation in this teaching experiment. From the results of the correspondence experiment we hope to improve our teaching methods and consequently offer better continuing education programs in the future.

Sincerely,

Phil R. Manning, M.D.
Associate Dean
Postgraduate Medical Education

PRM:mes
Encl - 1

ECG EXPERIMENT
IN
THE SPATIAL ANALYSIS OF THE ELECTROCARDIOGRAM

CORRESPONDENCE COURSE

	Average Scores	
	Pretest	Posttest
Narrative Text	16	27
Programmed Text	16	29

Your Score

Pretest -

Posttest -

APPENDIX - M

RAW DATA

CORRESPONDENCE COURSE

NARRATIVE TEXT

Identification Number	Pretest Score	Posttest Score	Time (min.)
5002	13	28	60
5003	26	24	
5004	25	30	
5005	18	29	
5009	18	23	
5010	25	30	65
5013	07	26	360
5015	25	30	180
5022	13	30	
5023	21	30	
5024	30	30	
5031	25	29	90
5032	08	06	300
5048	22	28	150
5061	17	30	
5062	21	28	120
5067	17	30	
5068	26	40	120
5069	06	22	
5071	24	27	90
5072	07	28	
5075	08	21	
5084	25	26	40
5088	21	29	
5092	08	25	
5097	19	30	90
5098	13	29	75
5099	00	17	90
5104	05	30	67
5105	07	15	
5107	17	28	
5108	25	28	
5110	00	29	50
5112	24	29	75
5121	07	30	105
5125	13	20	
5132	06	27	300
5135	05	30	

CORRESPONDENCE COURSE -continued

NARRATIVE TEXT - cont.

5137	06	23	150
5140	09	28	80
5141	00	28	
5146	07	30	
5149	20	25	240
5160	12	27	

RAW DATA

CORRESPONDENCE COURSE

PROGRAMMED TEXT

Identification Number	Pretest Score	Posttest Score	Time (min.)
6002	12	30	90
6005	13	27	180
6008	18	29	135
6011	28	30	90
6012	30	29	
6013	00	30	
6015	15	30	
6016	12	30	138
6017	16	28	
6024	05	28	150
6026	13	29	55
6029	13	29	90
6037	18	29	660
6039	18	30	
6041	26	30	85
6042	28	30	
6043	20	29	
6045	26	30	70
6049	09	25	75
6050	09	25	480
6051	15	30	90
6055	17	26	120
6058	29	30	
6064	10	23	240
6066	28	28	
6067	07	29	
6069	15	28	120
6071	10	29	180
6074	06	30	120
6079	22	29	135
6081	21	29	120
6082	00	25	
6090	28	30	62
6104	25	30	
6100	20	29	
6110	30	30	150
6112	08	29	60
6114	25	30	60

CORRESPONDENCE COURSE - continued

PROGRAMMED TEXT - cont.

6119	0[illegible]	30	180
6127	27	30	90
6129	24	30	95
6134	00	30	120
6136	05	27	90
6139	19	26	240
6146	19	29	
6140	19	30	
6141	08	28	60
6145	17	29	
6146	19	29	
6155	07	30	

APPENDIX - N

RAW DATA

LAS VEGAS

LECTURE-DEMONSTRATION

Identification Number	Pretest Score	Posttest Score	Time (min.)
1003	7	17	72
1004	18	22	72
1007	30	30	72
1008	6	23	72
1014	9	26	72
1016	28	29	72
1018	16	21	72
1023	10	23	72
1029	15	28	72
1037	5	28	72
1041	9	24	72
1051	22	21	72
1055	29	30	72
1056	30	30	72
1061	14	23	72
1064	30	29	72
1070	6	25	72
1072	27	28	72

LAS VEGAS - continued

PROGRAMMED TEXT

Identification Number	Pretest Score	Posttest Score	Time (min.)
2001	30	30	47
2002	23	30	48
2015	15	26	94
2019	28	28	76
2025	7	25	62
2030	17	29	83
2033	20	22	81
2038	28	30	92
2039	9	25	75
2040	16	27	68
2042	8	27	96
2045	29	29	44
2048	3	7	136
2050	18	26	99
2053	27	28	57
2054	29	30	59
2058	5	22	96
2063	30	30	50
2067	2	18	123
2071	27	30	52
2073	17	27	74
2074	16	29	98

LAS VEGAS - continued

LECTURE-WORKSHOP

Identification Number	Pretest Score	Posttest Score	Time (min.)
3009	2	27	117
3011	6	25	117
3012	7	19	117
3013	1	5	117
3017	26	29	117
3020	2	26	117
3021	14	17	117
3024	24	28	117
3026	28	23	117
3027	11	28	117
3032	25	27	117
3036	19	25	117
3046	0	29	117
3044	6	25	117
3047	10	23	117
3057	10	27	117
3059	1	8	117
3062	17	28	117
3065	24	24	117
3075	18	26	117

UNIVERSITY OF SOUTHERN CALIFORNIA
SCHOOL OF MEDICINE
2025 ZONAL AVENUE
LOS ANGELES, CALIFORNIA 90033
CAPITOL 5-1511

OFFICE OF THE ASSOCIATE DEAN
FOR POSTGRADUATE AFFAIRS

Reference is made to your participation in the teaching experiment that was held in Las Vegas, Nevada, January 18, 1968.

Our statistics show that all of the teaching methods were successful and about equal in so far as learning gain is concerned. The lecture-demonstration and programmed text accomplished about the same learning gain as the lecture-workshop, but in a significantly shorter time. Attached you will see the average scores and times for all three methods. You will also see your individual scores.

Once again, thank you very much for your participation in this teaching experiment. From the results we hope to improve our teaching methods and consequently offer better continuing education programs in the future.

Sincerely,

Phil R. Manning, M.D.
Associate Dean
Postgraduate Medical Education

PRM:mes
Encl - 1

LAS VEGAS, NEVADA ECG EXPERIMENT IN THE SPATIAL ANALYSIS OF THE ELECTROCARDIOGRAM

AVERAGE SCORES

Method	Pretest	Posttest	Mean Time
Lecture-demonstration	17	25	72 min.
Lecture-workshop	13	23	117 min.
Programmed text	18	26	78 min.

YOUR SCORE

Pretest -

Posttest -

APPENDIX - O

RAW DATA

FRESHMAN MEDICAL STUDENTS

PROGRAMMED TEXT

Identification Number	Pretest Score	Posttest Score	Time (min.)
101	0	27	70
104	0	29	66
108	2	30	52
109	4	28	86
112	0	29	82
113	0	29	73
116	6	27	95
119	0	30	105
120	7	26	89
124	0	27	72
128	6	28	75
132	0	29	96
136	0	29	70
137	0	23	83
139	6	20	75
140	0	28	85
141	6	30	121
142	0	27	62
143	0	27	66
144	0	30	89
152	0	30	80
156	0	9	115
157	0	28	88
160	0	30	71
161	0	27	78
164	0	30	96
166	1	30	77
169	0	30	85
170	19	30	71
171	0	28	93
172	1	29	66

FRESHMAN MEDICAL STUDENTS - continued

NARRATIVE TEXT

Identification Number	Pretest Score	Posttest Score	Time (min.)
202	2	26	72
203	23	29	40
205	1	18	37
206	6	30	60
207	11	21	60
210	5	27	60
214	0	23	53
215	2	30	56
217	0	30	104
218	5	29	35
221	0	26	41
222	0	24	80
223	0	29	70
225	1	21	51
226	1	24	64
227	0	27	62
229	2	29	77
230	3	27	94
231	0	30	73
233	0	30	54
234	0	29	59
235	0	24	62
238	0	26	60
245	0	27	81
246	0	27	89
248	1	28	96
249	6	28	60
250	7	16	74
251	0	26	50
253	0	12	79
262	0	26	79
263	0	28	75
265	0	28	53
267	0	28	73
273	0	30	59
268	1	30	45

Thank you very much for your participation in the teaching experiment which utilized the plotting of the mean cardiac vectors. Attached you will see the mean scores and time requirements for both of the methods. Also, your individual results are included.

Once again, thank you for your participation in the experiment. Through experiments of this kind it is hoped that our teaching methods can be improved.

Sincerely,

Phil R. Manning, M.D.
Professor of Medicine
Postgraduate Medical Education

PRM:ms

Freshman Medical Students

ECG EXPERIMENT
IN
THE SPATIAL ANALYSIS OF THE ELECTROCARDIOGRAM

	Average Scores		Mean Time
	Pretest Mean Score	Post test Mean Score	
Programmed Text	1	27	82 Minutes
Narrative Text	2	25	66 Minutes

Your Pretest Score -

Your Post test Score -

APPENDIX - P

APPENDIX - P

PATIENT: N.C., P.F.#274-09-72

PRESENT ILLNESS: This 29-year-old Caucasian female was first seen by a member of the Liver Service in April, 1967. No medical records of the patient's prior history were available. A presumptive diagnosis of Wilson's disease had been made approximately 14 years ago.

At approximately the age of 12 years, Miss Crane began to develop tremors of her upper and lower extremities, which apparently progressed rapidly, resulting in inability to write and eventual removal of the patient from school. During the past 14 years, the neurologic disorder has been steadily progressive, and in the past few months has been associated with mental deterioration and inability of the patient to ambulate without aid. At age 16 years, the patient was seen at the White Memorial Hospital, where the mother states a Kayser-Fleischer ring was observed by a house officer. A presumptive diagnosis of Wilson's disease was made at that time. About ten years ago, a neurosurgical procedure was performed (pallidectomy), but was terminated due to excessive bleeding. The patient has never received penicillamine or BAL therapy. Dilantin has been administered for the past six years. Jaundice, ascites, edema and G.I. bleeding have never occurred.

FAMILY HISTORY: The patient's mother has been married on

three occasions. Three daughters were products of the first marriage, one of whom is the propositus; the other daughters are apparently healthy. The patient's mother has a son by a second marriage who is known to have some form of chronic liver disease.

PHYSICAL EXAMINATION: (May, 1967) The general appearance is that of a well-developed, well-nourished Caucasian female with uncontrollable flapping tremor of all extremities, a "fixed smile", and severe dysarthria. Blood pressure 114/70, pulse 80 and regular.

HEENT	A clear-cut Kayser-Fleischer ring is evident at the limbus of both cornea.
Lungs	The lungs are clear to auscultation and percussion.
Heart	There is no cardiomegaly and no murmurs are auscultable.
Abdomen	Flat and tender. There is no evidence of ascites. The liver is palpably enlarged, extending approximately 2 to 3 cm. below the right costal margin with inspiration. The spleen is similarly palpable, approximately 2 to 3 cm. below the left costal margin. No venus hum is evident and no bruits are auscultable.
S & E	No distinct spider angiomata are evident. There is no clubbing of the fingers.
Neurological	A gross intention tremor associated with cog-

wheel rigidity is present. The deep tendon reflexes are equal and quite active.

LABORATORY:

Test (normal)	5/12/67
Hgb.	14.6
PCV	45
WBC	2800 -- normal differential
BUN	7
Creatinine	0.8
Uric acid	2.1 and 2.6
Calcium	4.2
Phosphate	2.7 and 4.0

LFT's

A/G	4.4/2.8
Bilirubin/direct	1.1/0.2
Alkaline phosphatase	2.5
SGOT	24
SGPT	28
Prothrombin time	74%
BSP (30 minutes)	9%
Ceruloplasmin (280-570 u.)	52 units

24-hour urine (5/29/67)

Copper (N=up to 30)	1080 ug./24h.
Creatinine (female--16--22)	744

COURSE: Penicillamine therapy, 3 grams per day, was initiated on April 15, 1967. The members of the patient's family feel there has been some distinct improvement during the past 2-1/2 months, with better ability to walk unaided, better mentation, and some decrease in her tremors.

Liver biopsy was performed on May 18, 1967. Quantity was insufficient for copper determination.

APPENDIX - Q

DIRECTIONS

Each question, in this test, is followed by 5 suggested answers. Select the one (or ones) which is (are) correct in each case and then circle the appropriate number(s).

Identification Number ______________

A. Which of the following presenting signs or symptoms is (are) quite compatible with Wilson's disease? (Circle 1 or more answers)

1. A neurologic disorder thought to be Parkinson's disease in a 34-year-old woman.

2. Hemiparesis of recent onset in a 55-year-old woman with headaches.

3. Glycosuria with a normal glucose tolerance test in a 32-year-old man with a palpable liver.

4. Hematemesis from ruptured esophageal varices in a previously asymptomatic 72-year-old man.

5. Ascites and hepatic coma in a 12-year-old boy.

B. With regard to the family history of a patient with Wilson's disease, which of the following is (are) correct? (Circle 1 or more)

6. Both parents are carriers but do not have the clinical disease; about one quarter of the siblings will have the disease.

7. The disease is seen in successive generations. About half of the children, male and female, of an affected parent will have the disorder.

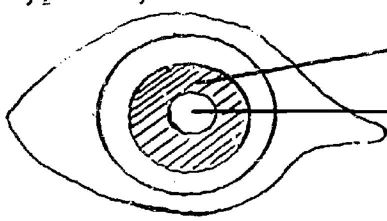
8. There is an increased likelihood of consanguinity in parents of affected children.

9. The disease is found only in males with women being carriers and not having clinical illness. There is no father-to-son transmission.

10. Homozygosity is required for clinical disease; heterozygotes have no clinical illness.

C. Which of the following statements is (are) correct about the Kayser-Fleischer ring? (Circle 1 or more answers)

11. It is relatively easy to distinguish from an arcus senilis.
12. It is blue-gray in color.
13. It may require a slit lamp for visualization.
14. It may disappear with prolonged therapy.
15. It is typically located as shown in this diagram.



D. Patients with Wilson's disease commonly exhibit neurologic manifestations, such as: (Circle 1 or more)

16. Involuntary movements.
17. Calcifications in the basal ganglia seen on x-ray.
18. Tremor as a prominent manifestation.
19. Spastic paraplegia with increased deep tendon reflexes.
20. Mental changes accompanying the advanced disease.

E. In Wilson's disease, laboratory manifestations could include: (Circle 1 or more answers)

21. A low total serum copper with a high free copper level.
22. A high serum uric acid.
23. A low serum ceruloplasmin.
24. A high urine copper excretion.
25. A lower than normal radioactive copper uptake from the gut.

F. Correct statements about the pathology in Wilson's disease could include: (Circle 1 or more)

26. Fatty change in the liver is common in the absence of alcoholism.

27. Liver fibrosis without true regenerative nodules is the rule.

28. Copper can be detected in the liver by the use of a special stain.

29. No other liver disease has a high concentration of liver copper.

30. The copper content of brain and cornea are increased.

G. With regard to the renal tubular abnormalities of Wilson's disease, which of the following is (are) correct? (Circle 1 or more answers)

31. Phosphorus clearance is often high.

32. There may be glycosuria with a normal serum glucose.

33. The renal tubular abnormalities are thought to be due to congenital enzyme deficiencies.

34. Total urinary amino-acid excretion is increased.

35. A characteristic pattern of specific urinary amino-acids is demonstrable by chromatography.

H. In the treatment of Wilson's disease, which of the following is (are) correct? (Circle 1 or more answers)

36. Appreciable improvement is unlikely once definite neurologic symptoms and signs have appeared.

37. A low copper diet is used.

38. BAL (British anti-lewisite), given by injection, is the mainstay of therapy.

39. Serum ceruloplasmin tends to return toward normal during prolonged treatment.

40. Therapy that causes a urine copper excretion of 200 micrograms per 24 hours is generally regarded as satisfactory.

I. In Wilson's disease, which of the following statements is (are) correct? (Circle 1 or more answers)

41. Heterozygotes can be detected by chromosomal analysis.
42. Neurologic manifestations are more common before the age of 20 and hepatic manifestations are more common after the age of 20.
43. Intrasplenic pressure may be considerably higher than wedged hepatic vein pressure in the presence of portal hypertension.
44. Transaminase levels over 1,000 units are frequently seen during jaundiced episodes.
45. Quantitative determination of copper can be made on needle liver biopsy specimens.

J. With modern therapy for Wilson's disease which of the following is (are) correct? (Circle 1 or more answers)

46. Allergic manifestations, including skin rashes and eosinophilia, may be seen during the early phases of treatment.
47. Urinary copper is increased.
48. There is little likelihood of improvement in the liver disease.
49. Nephrotic syndrome has been reported as a complication of therapy.
50. This therapy should be undertaken in asymptomatic patients with the disease.

APPENDIX - R

RAW DATA

WILSON'S DISEASE

INTENSIVE REVIEW
OF INTERNAL MEDICINE

GROUP I

Identification Number	Pretest Score	Posttest Score
1002	31	35
1003	33	36
1004	34	50
1006	28	43
1013	30	48
1016	34	44
1019	35	47
1025	31	46
1026	31	48
1028	29	30
1029	43	49
1034	34	47
1035	36	49
1036	34	46
1046	36	48
1049	28	46
1072	26	47
1074	35	47
1076	35	49
1077	45	50
1084	35	45
1092	33	49
1096	30	49
1098	29	40
1099	33	47
1100	40	50
1101	44	49
1103	28	45
1108	34	50
1112	37	47
1119	25	40
1124	35	46
1125	30	47
1127	36	47
1137	40	48
1144	30	47

WILSON'S DISEASE - continued

INTENSIVE REVIEW - continued

1163	26	38
1164	32	48
1166	35	46
1168	35	49

WILSON'S DISEASE - continued

INTENSIVE REVIEW
OF INTERNAL MEDICINE

	Identification Number	Pretest Score	Posttest Score
GROUP II	2001	34	46
	2005	31	46
	2008	34	47
	2010	32	48
	2014	34	47
	2015	40	49
	2021	30	42
	2022	26	47
	2030	30	47
	2032	43	48
	2047	34	46
	2051	33	43
	2054	35	44
	2056	41	49
	2061	36	47
	2063	28	48
	2065	36	45
	2066	32	46
	2069	29	49
	2071	28	40
	2080	40	50
	2083	30	43
	2086	33	46
	2091	30	47
	2095	29	42
	2105	34	46
	2106	42	50
	2110	35	48
	2115	29	46
	2118	27	46
	2128	40	49
	2129	25	42
	2130	22	42
	2131	37	46
	2136	29	44
	2139	32	47
	2140	34	41

WILSON'S DISEASE - continued

INTENSIVE REVIEW - cont.

GROUP II - cont.	2141	32	42
	2145	38	48
	2146	26	47
	2150	29	40
	2151	32	47
	2154	33	43
	2158	32	44
	2160	36	48
	2161	24	43
	2172	35	46
	2176	33	49

WILSON'S DISEASE - continued

INTENSIVE REVIEW
OF INTERNAL MEDICINE

	Identification Number	Pretest Score	Posttest Score
GROUP III	3009	25	46
	3011	30	49
	3017	25	49
	3018	18	46
	3020	37	49
	3023	33	49
	3024	38	50
	3027	35	49
	3031	25	48
	3033	28	42
	3037	30	49
	3039	24	28
	3050	38	47
	3052	36	46
	3053	36	47
	3057	33	48
	3062	38	47
	3064	22	46
	3067	29	43
	3073	39	50
	3078	24	47
	3079	31	40
	3082	39	47
	3085	30	48
	3087	22	40
	3090	42	48
	3093	31	48
	3094	34	48
	3111	32	47
	3114	42	48
	3116	23	39
	3117	36	48
	3120	40	49
	3122	25	47
	3123	39	49
	3132	35	44
	3133	25	27

WILSON'S DISEASE - continued

INTENSIVE REVIEW - cont.

GROUP III	3142	35	50
	3143	36	50
	3038	27	48
	3147	34	50
	3198	41	49
	3170	36	50
	3174	27	48
	3175	37	48

WILSON'S DISEASE - continued

BEDSIDE CLINICS AND SET CLINICS IN INTERNAL MEDICINE

	Identification Number	Pretest Score	Posttest Score
GROUP IV	4002	31	41
	4004	34	47
	4006	26	41
	4013	31	45
	4016	24	43
	4017	27	44
	4018	33	48
	4020	24	38

WARD WALKS IN RARE DISEASES

GROUP V	5001	34	47
	5002	38	45
	5003	24	43
	5004	36	43
	5005	34	48
	5008	30	39
	5009	29	46
	5010	34	45
	5011	32	43
	5013	31	39
	5014	40	47
	5015	32	44
	5021	34	44
	5022	34	48
	5024	32	40

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INTERVIEWS

Wolf, Richard M., Procedures suggested September, 1967.

FINANCIAL REPORT

FINANCIAL REPORT

U.S. PUBLIC HEALTH GRANT PH 108 66 263

Expense Commitments to July 31, 1968

Personnel - Salaries	$ 26,948.06
Equipment	1,152.30
Material and Supplies	2,072.49
Communications	120.60
Services	4,593.21
Travel	1,587.19
Total	$ 36,473.85